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March 2003

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Galaxies in Corvus, Crater, and Sextans

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Our editors review 10 finder scopes

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The largest-selling serious telescopes in the world: Meade LX90 and LX200GPS Schmidt-Cassegrains.

In virtually every country in the world where serious telescopes are sold, more Meade LX90 and LX200GPS Schmidt-Cassegrains are sold than all competing models *combined.* In fact, leading telescope dealers report that Meade 8", 10", 12", and 14" Schmidt-Cassegrains now outsell competing Schmidt-Cassegrains *by more than three to one.*

The reasons for this overwhelming acceptance of Meade LX90 and LX200GPS telescopes are clear: advanced technology at the very leading edge of telescope design and including the patented Autostar control system; legendary diffraction-limited optical systems with optionally-available ultra-high transmission coatings; and uncanny 1-arcminute High-Precision Pointing in the GO TO mode that positions objects on even the smallest CCD chips.

Little wonder that, by any comparison, Meade LX90 and LX200GPS Schmidt-Cassegrains are the telescopes chosen by advanced amateurs worldwide for their visual, photographic, and CCD applications.

8" LX90	*reg.* **$1695;** *now*	**$1495;**	*save* **$200**
8" LX200GPS	*reg.* **$2495;** *now*	**$1995;**	*save* **$500**
10" LX200GPS	*reg.* **$2995;** *now*	**$2495;**	*save* **$500**
12" LX200GPS	*reg.* **$3495;** *now*	**$2995;**	*save* **$500**
7" LX200GPS	*reg.* **$2995;** *now*	**$2495;**	*save* **$500**

Ultra-High Transmission Coatings (UHTC) group: 8" LX90 or 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 14" LX200GPS – $350; 7" LX200GPS Maksutov-Cassegrain – $150.

Packing & shipping charges in the 48 states: 8" LX90 – $95; 8" LX200GPS – $105; 10" – $145; 12" – $215; 14" – $265; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices. Certain Meade telescopes and Autostar control systems are manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide. Special LX90 and LX200GPS prices are valid for purchases from authorized Meade dealers in the U.S.A. **between September 15, 2002 - February 28, 2003.**

Buy a $650 Super Plössl eyepiece set for your LX90 or LX200GPS for only $99!

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Through February 28, 2003, you can buy a full set of Meade premium-grade Series 4000 Super Plössl eyepieces, packed in a Meade #771 aluminum carrying case, for only **$99** with the purchase of a Meade LX90 or LX200GPS telescope. *See the Meade ad on the back-cover of this issue for complete terms and conditions on this amazing offer.*

AUTHORIZED MAIL-ORDER DEALERS

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Orders: 800-422-7876; Info.: 405-364-0858.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

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Orders & Info.: 800-621-2248; IL: 847-367-4600.

WOODLAND HILLS CAMERA & TELESCOPE, Woodland Hills, CA.
Orders: 888-427-8766; Info.: 818-347-2270.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

EFSTONSCIENCE, Toronto, Ontario, Canada
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

DPM Library

A Comparison of GPS Schmidt-Cassegrain Telescopes

	Meade LX200GPS	Competing 8" and 11" GPS
Primary Mirror Lock	Yes; standard equipment. Cancels residual mirror shift during visual, photographic, or CCD imaging applications	No
Zero Image-Shift Microfocuser	Yes; standard equipment. Operates from Autostar II handbox and permits 4-speed microfocusing, while maintaining precise image centration during CCD imaging	No; must be purchased separately from an alternate supplier at a cost of approx. $200 to $300
Download of Software Revisions	Yes; the latest software version, as well as custom and updated guided tours, comet and asteroid positions, may be downloaded in minutes, and at no charge, from the Meade website	No; software and data stored in the hand controller are not updatable without returning the hand controller to the factory; motor control software upgrade or debugging requires complete replacement of the electronic circuit board in the fork arm assembly
Software Download, Automatic GO TO, and Automatic Tracking of Earth Satellites	Yes; current earth satellite orbital data (including International Space Station, Space Shuttle, etc.) may be downloaded; telescope then automatically acquires and tracks satellite at correct tracking rate	No
True-Level Tripod Sensor	Yes; automatically compensates to a precision of 10-arcminutes for user error in leveling tripod during GPS alignment	No; absence of true-level sensor requires user to precisely level the tripod **manually**. Mis-leveling of the tripod by user results in alignment star errors of up to 5° or more during GPS alignment
Maximum Slew Speed	8° per second	3° per second
Time Required to Perform a 120° Slew	15 seconds	40 seconds
Drive Speeds, each axis	185 speeds, from 0.01x sidereal to 8° per second	9 speeds, from 0.5x sidereal to 3° per second
Tracking Rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Celestial Object Database	147,541 objects	40,000 objects
High-Precision Pointing Mode	Yes; permits GO TO pointing precision within 1-arcminute	No
Flash Memory	3.5-Meg	1.0-Meg
Permanent Periodic Error Correction	Yes, both axes	One axis only; second axis unprogrammable
Encoder Resolution	0.14 arcsecs	0.26 arcsecs
Internal Battery Compartments for cordless powering	Yes; user-supplied C-cell batteries located inside the fork arms negate any need for external power cords. (If desired, telescopes may alternately be powered by external cord.)	No
Multi-Coated Correcting Plate	Included with optional UHTC; increases light transmission by about 2% and reduces internal tube reflections	Not included and not available as an option
Enhanced Optical Coatings	Optional UHTC group results in light transmission **greater than 85%** at **all** wavelengths between 450nm - 700nm and transmission of **90% to 94%** at wavelengths between 540nm - 690nm, a range which includes the important Hα line at 656nm	Competing 11" coatings have a **peak** transmission of 85% at 510nm; **light transmission at all other visual wavelengths, including the Hα line, is below 85%**
Hand-Matched Optics	Yes; since their inception in 1980 all Meade Schmidt-Cassegrain optics have been individually hand-matched. Individual match-figuring is performed on the large correcting plate, resulting in a smooth optical figure	Yes; individual matching is performed on the small secondary mirror
Primary Mirrors	Oversize diameters (8.25" on 8" LX200GPS; 10.38" on 10" LX200GPS; 12.38" on 12" LX200GPS) result in increased edge-of-field illumination	Mirror diameters (8" telescope includes 8.1" mirror; 11" includes 11.1" mirror) result in lower edge-of-field illumination
GPS Antenna	Omnidirectional, located squarely on top of fork arm; GPS signals are receivable through a larger sky-area	Omnidirectional, but location at approx. 45° angle inside fork arm results in approx. 45° sky-area being inaccessible to GPS signals
Field Tripods	8" and 10" tripods include 2"-dia. chromed steel legs; 12" and 14" tripods include 3"-dia. chromed steel legs; all tripods include a **cast aluminum** leg-lock spreader bar	8" and 11" tripods include 2"-dia. painted steel legs and a **plastic** leg-lock spreader bar
Polar Axis Bearings	1 x 4" dia. ball bearing and 1 x 2.25" dia. ball bearing mounted coaxially to the polar axis. Both bearings contribute to radial and axial stiffness	1 x 1.88" dia. roller bearing mounted coaxial to the polar axis and 3 x 0.88" dia. ball bearings rolling on an unshielded aluminum track. Only the 1.88" bearing contributes to radial stiffness
Swing-through of optical tube in fork arms	Yes; telescope can observe 100% of sky area	Yes; telescope can observe 100% of sky area
FCC (U.S.A.) and CE (Europe) certified for low electromagnetic interference	Each telescope carries a label confirming FCC and CE certifications	Telescopes do not carry any labels confirming domestic or foreign certifications

Comparisons are based on current Meade LX200GPS models and on competitive telescopes and user manuals received in 11/2002.

New 2002 - 2003
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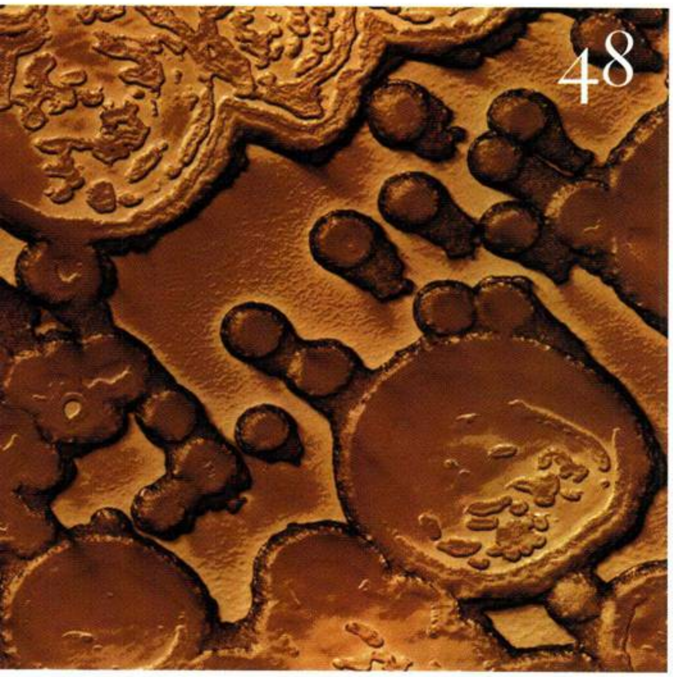

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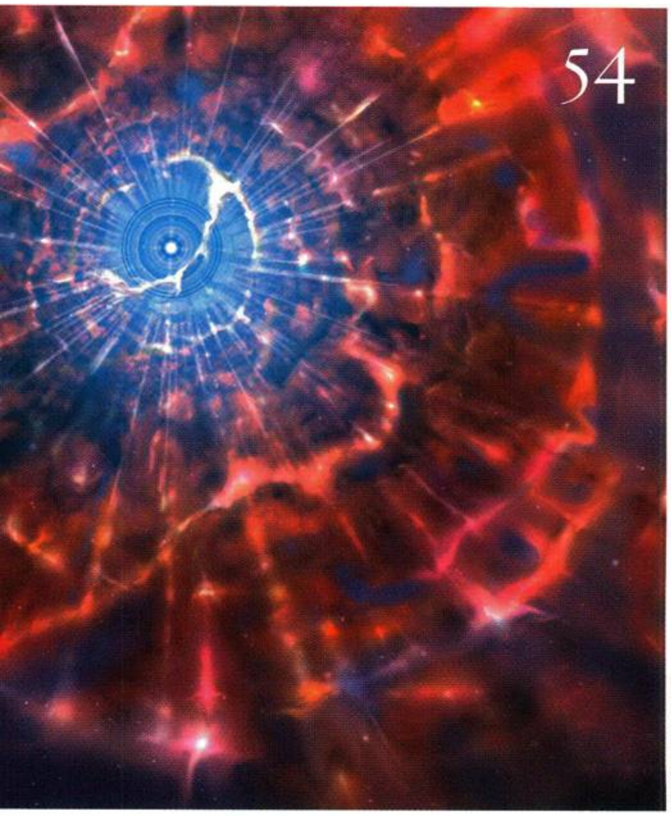

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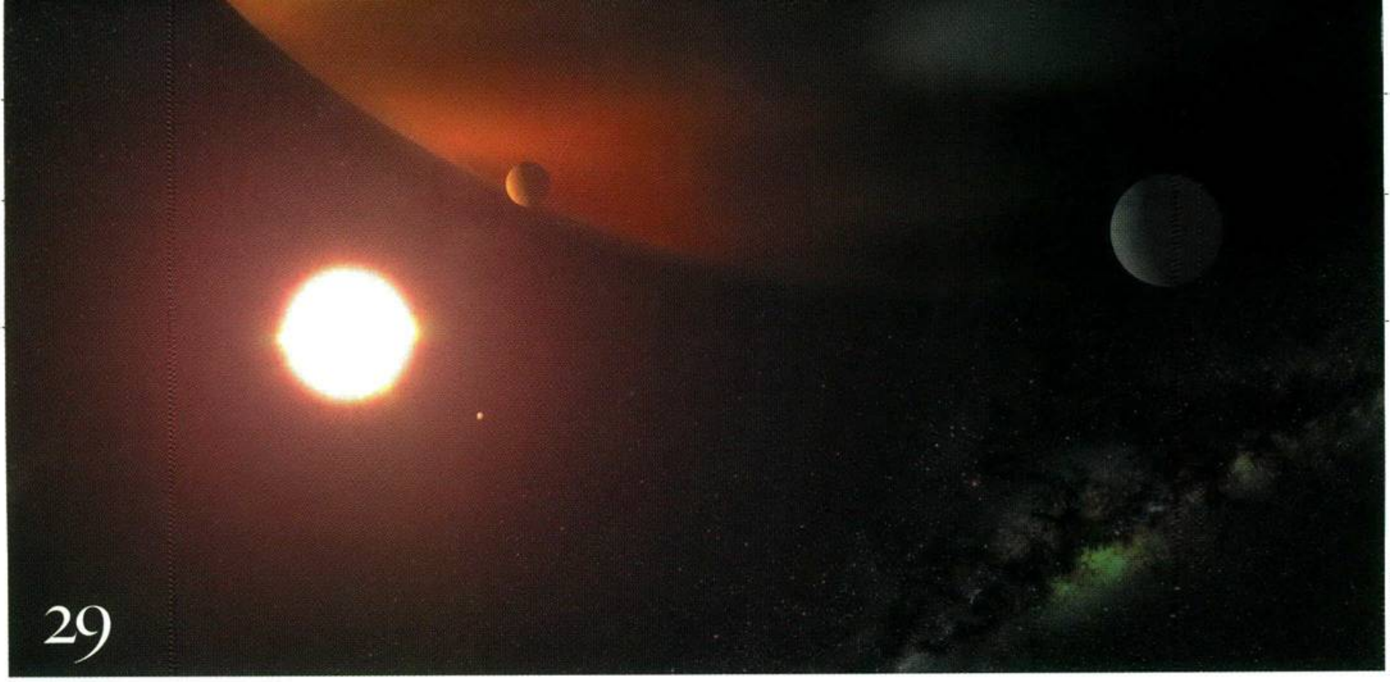

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ON THE COVER
Dark energy will ultimately separate the bright matter of the cosmos, like the Whirlpool Galaxy, into eternal darkness. This image of the Whirlpool, also known as M51, was shot with the 3.6-meter Canada-France-Hawaii telescope on Mauna Kea, Hawaii. The image was shot by Jean-Charles Cuillandre using B, V, and Hα filters, and composited into a final digital frame. CANADA-FRANCE-HAWAII TELESCOPE/J.-C. CUILLANDRE/COELUM

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FADING TO BLACK: an animation illustrating how the universe darkens with time

MARS POLAR LANDER: What if it had succeeded?

MARS AT OPPOSITION: maps and observing tips

STELLAR COLLAPSE: See how a neutron star forms.

CCD CAMERAS: more info on digital astrophotography

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BY DAVID J. EICHER

The new *Astronomy*

When I was 15, I first dreamed of becoming editor of *Astronomy* magazine. Last summer, after 20 years of working on the title, that dream was fulfilled. The timing coincided with a number of focus group surveys our management held to explore how *Astronomy* could better serve its readers. With a circulation of 160,000, *Astronomy* is by far the world's largest and most successful publication focused on its subject. However, we found that readers did want some adjustments in the magazine. We talked with numerous people, held lots of meetings, and dreamed up the ideal publication for astronomy enthusiasts — one that covers all the bases and hits all the hot areas of the hobby and of the science. Our team — editors, artists, publisher, and our mates in circulation and advertising — buckled down to create the best product we could assemble. We hired a talented group at a New York design firm, Iridium, to give our new magazine the best possible look. You hold the result — the first new *Astronomy* — in your hands.

"*Get back to where you once belonged.*" So wrote Paul McCartney in his 1969 Beatles mantra. Essentially, that's what *Astronomy* is doing. We are expanding the editorial space in the magazine by 15 percent. We are using that space to give you more of the best of *Astronomy*'s classic style of covering the science and the hobby. This return to the roots occurs in the magazine's 30th anniversary year.

The differences in the hobby section will be most striking. Every issue will now contain at least one article covering each of the major categories of interest in the hobby: deep-sky observing; lunar and planetary observing; conventional film and CCD digital imaging; and equipment reviews. We are doubling the equipment coverage in the magazine by providing an in-depth telescope review and a survey of a product category every month.

The improvements don't stop with the hobby articles, however. We are providing the best, most detailed, and most clearly written stories on astronomical discoveries on the planet. These will run the gamut from the solar system to Milky Way discoveries to galaxy clusters and the edge of the observable universe, using the best and most exciting imagery available. We also have added some new features, such as a monthly interview with a distinguished astronomer, as well as old favorites like *Bob Berman's Strange Universe* and *Glenn Chaple's Observing Basics.*

We're also pleased to tell you that we have reinvented the star maps in *Astronomy*. They now look more handsome under white light but — most critically — also function far more effectively under dim red light, at the telescope. Please note new star scaling, larger labeling, and a beautiful cobalt blue background. We think you'll like them.

Indeed, we believe you will like the changes in the new *Astronomy*. We will continue to evolve the magazine to make it the best friend you can have in the hobby and in your intellectual journey into the cosmos. Please let me know what you think as you receive new issues, at editor@astronomy.com. I'll be listening.

Yours truly,

DAVID J. EICHER
Editor

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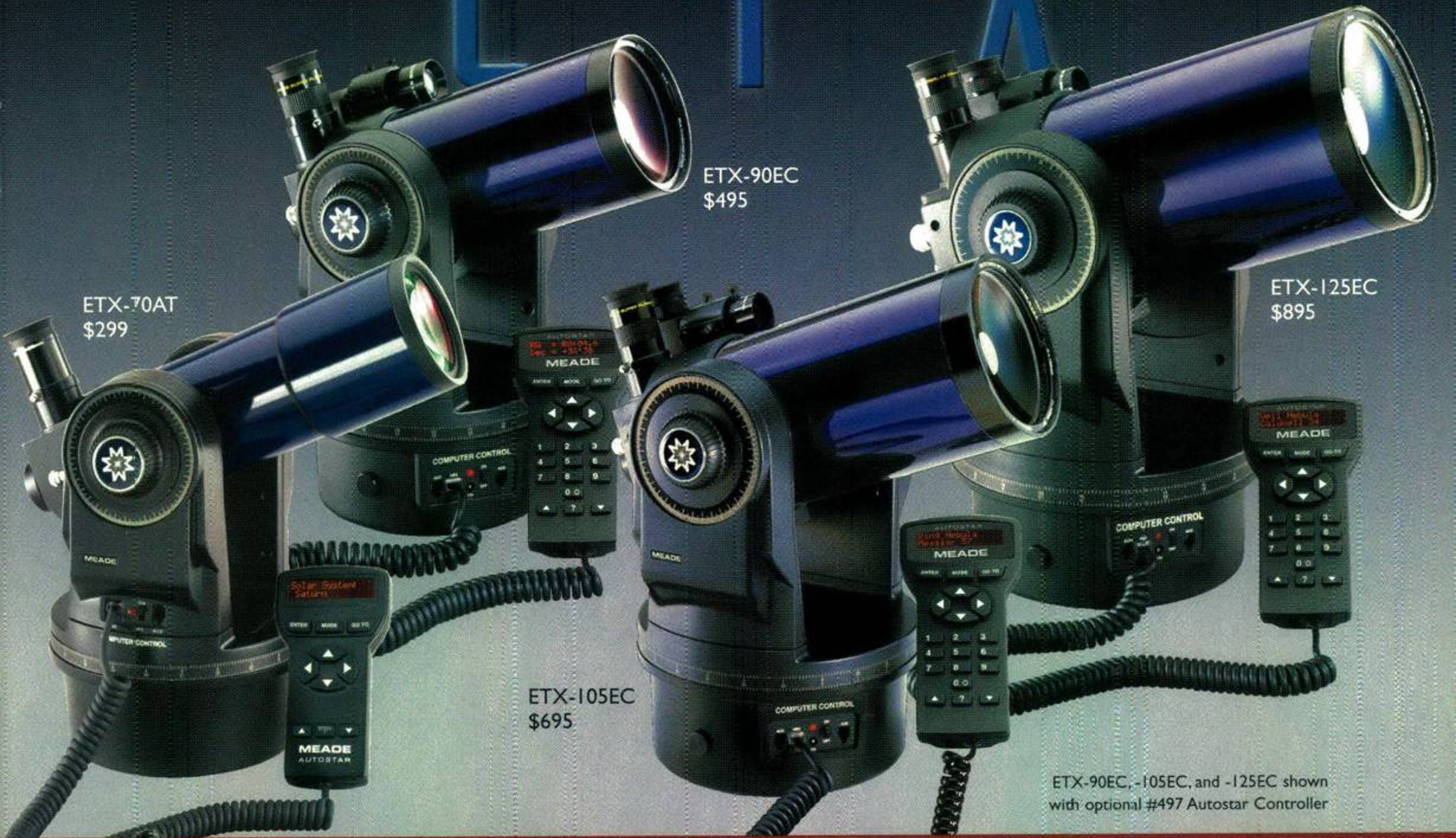

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Complete per catalog specifications:

ETX-70AT with #494 Autostar and #882 Field Tripod	$299
ETX-90EC with Electronic Controller	495
ETX-105EC with Electronic Controller	695
ETX-125EC with Electronic Controller	895
#497 Autostar controller for ETX-90EC, ETX-105EC, or ETX-125EC	149

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90EC– $50; ETX-105EC– $75; ETX-125EC– $95

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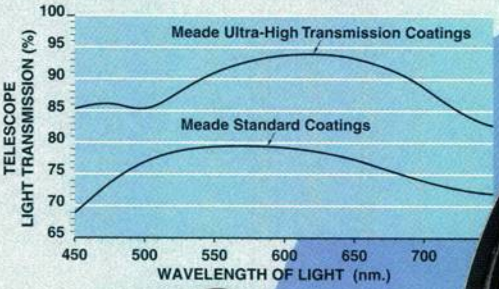

Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.

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Meade Model SC-8
8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
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6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

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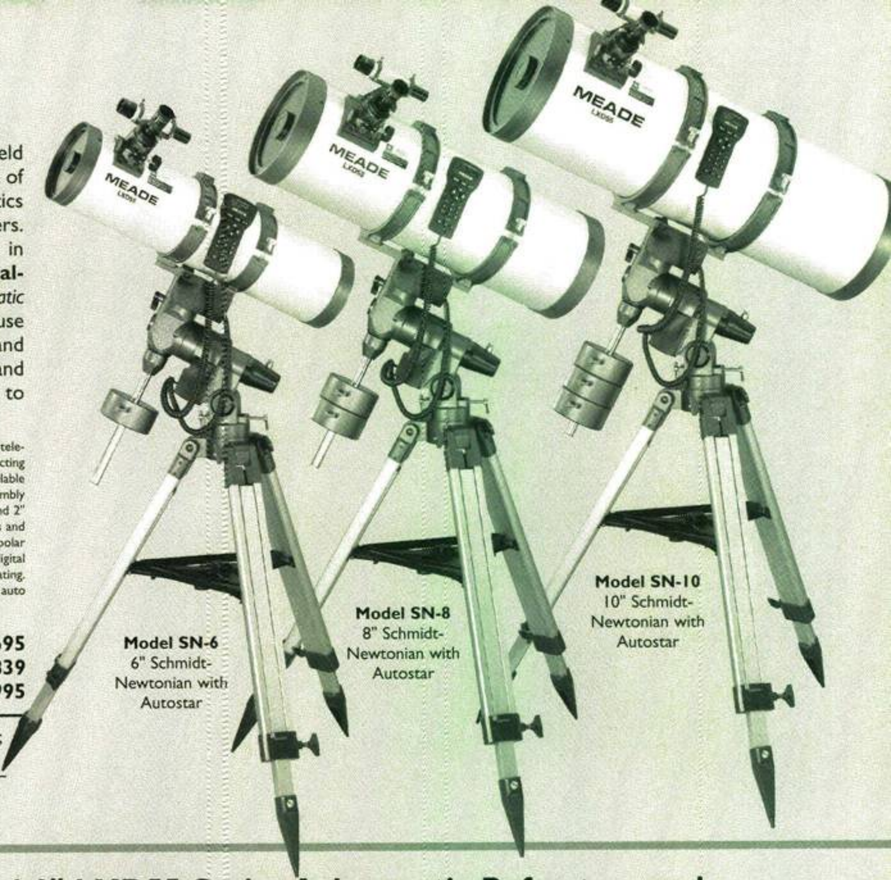
SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.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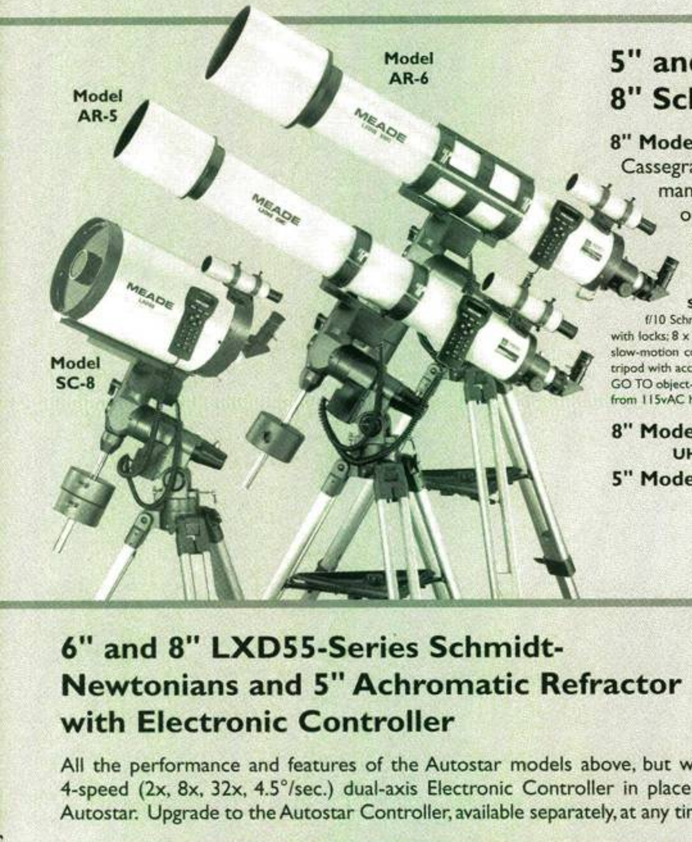
Model SN-10
10" Schmidt-Newtonian with Autostar



5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

SPECIFICATIONS: Models SC-8 Schmidt-Cassegrain and AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 8" f/10 Schmidt-Cassegrain with MgF_2/standard coatings or 5" f/9 or 6" f/8 achromatic refractor with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm viewfinder; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

8" Model SC-8 Schmidt-Cassegrain . . $1195

UHTC group for Model SC-8 — $175

5" Model AR-5 Achromatic Refractor . . 695

6" Model AR-6 Achromatic Refractor . . 895

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; 4.5°/second for rapid-slew of the telescope across the sky; plus automatic sidereal-rate RA tracking. ***#497 Autostar Controller may be added at any time in the future and permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2003

MEADE
MEADE
MEADE
Model SN-6EC
6" Schmidt-Newtonian with Electronic Controller
Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller
Model AR-5EC
5" Achromatic Refractor with Electronic Controller

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each: **$79.95** (4.54)
32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated: 1.25".

$59.95 (4.54)

New! 2" Diagonal Mirrors with UHTC

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$119.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

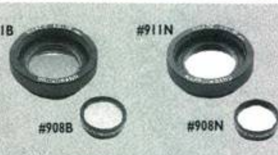
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (*far right in photo*), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)



Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

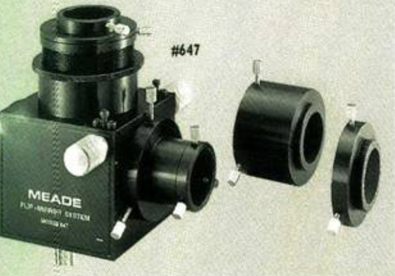
#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

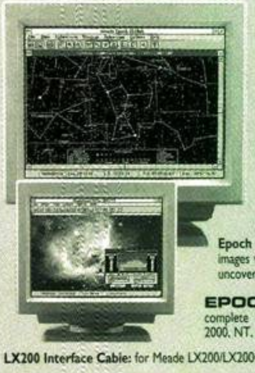
#647



#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk.......... **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

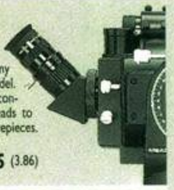
Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

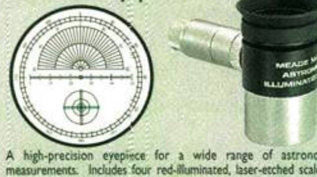
#932 45° Erecting Prism for ETX®



For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models: **99.95** (8.58)

#776 Case for ETX-105EC: **99.95** (8.58)

#775 for ETX-125EC: **149.95** (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

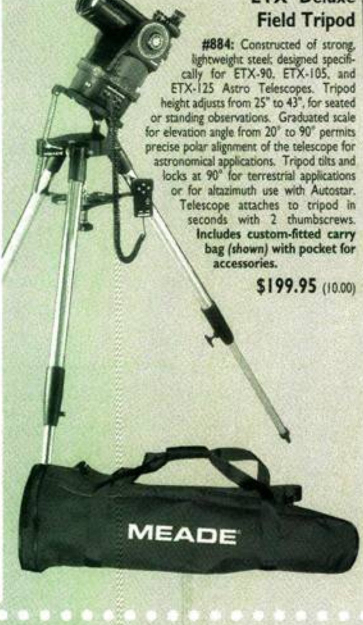
#670 for ETX-60/70 .... **19.95**
#673 for ETX-90....... **24.95**
#675 for ETX-105...... **27.95**
#678 for ETX-125...... **29.95**

Pictor 216XT CCD Autoguider/Imager

The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotgraphy.

$695. (12.00)

ETX® Deluxe Field Tripod



#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)

#771 Aluminum Carrying Case

High-quality, lightweight aluminum, suitable for storage of eyepieces, camera adapters, filters, etc. Fully foam-lined. 15" x 10" x 5".

$49.95 (5.78)

Advanced Field Tripod for ETX-125

#887: Yields rock-solid stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models: **$119.95** (6.85)

#1247 Electric Focuser for ETX-125 models: **$119.95** (6.85)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

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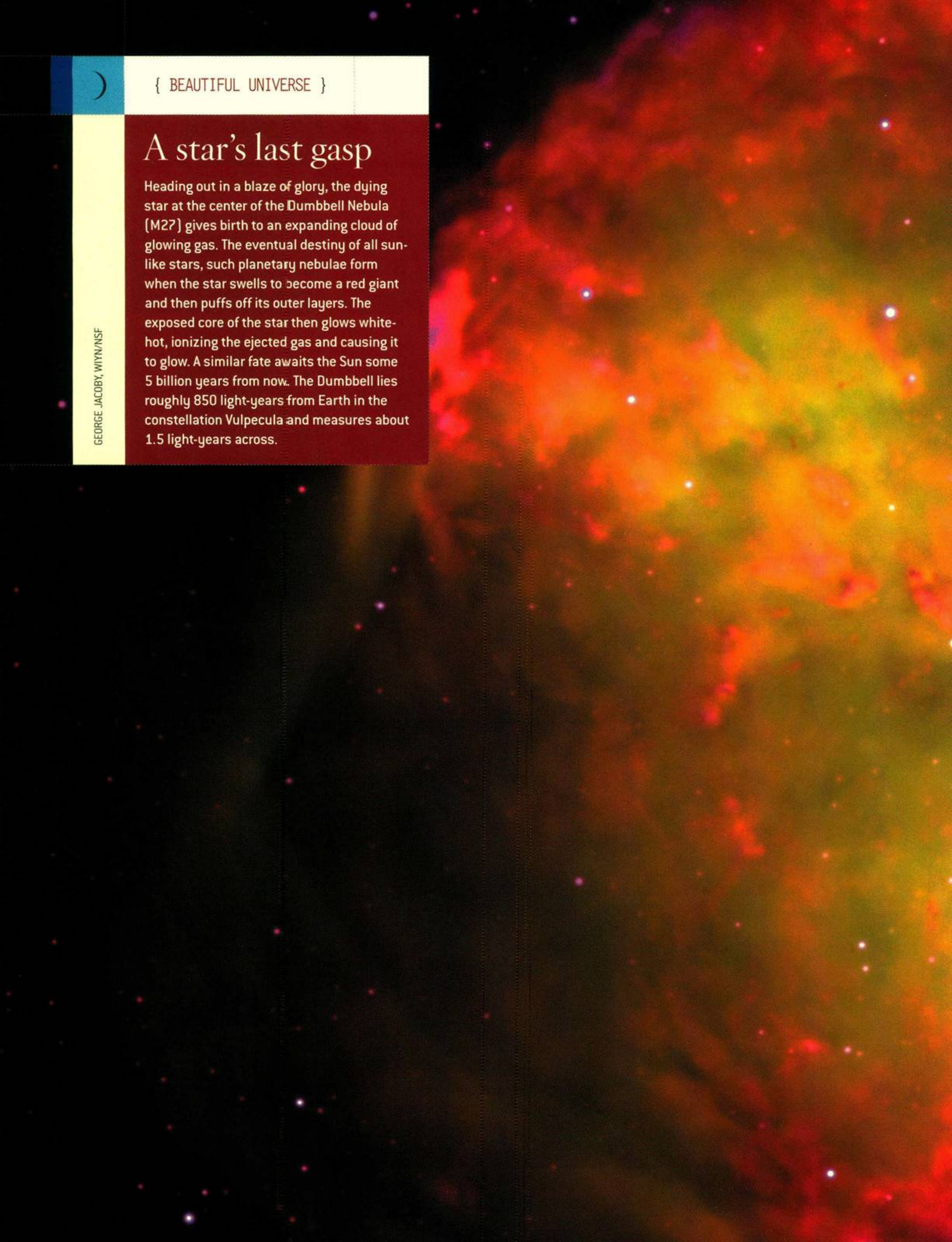
A star's last gasp

Heading out in a blaze of glory, the dying star at the center of the Dumbbell Nebula (M27) gives birth to an expanding cloud of glowing gas. The eventual destiny of all sun-like stars, such planetary nebulae form when the star swells to become a red giant and then puffs off its outer layers. The exposed core of the star then glows white-hot, ionizing the ejected gas and causing it to glow. A similar fate awaits the Sun some 5 billion years from now. The Dumbbell lies roughly 850 light-years from Earth in the constellation Vulpecula and measures about 1.5 light-years across.



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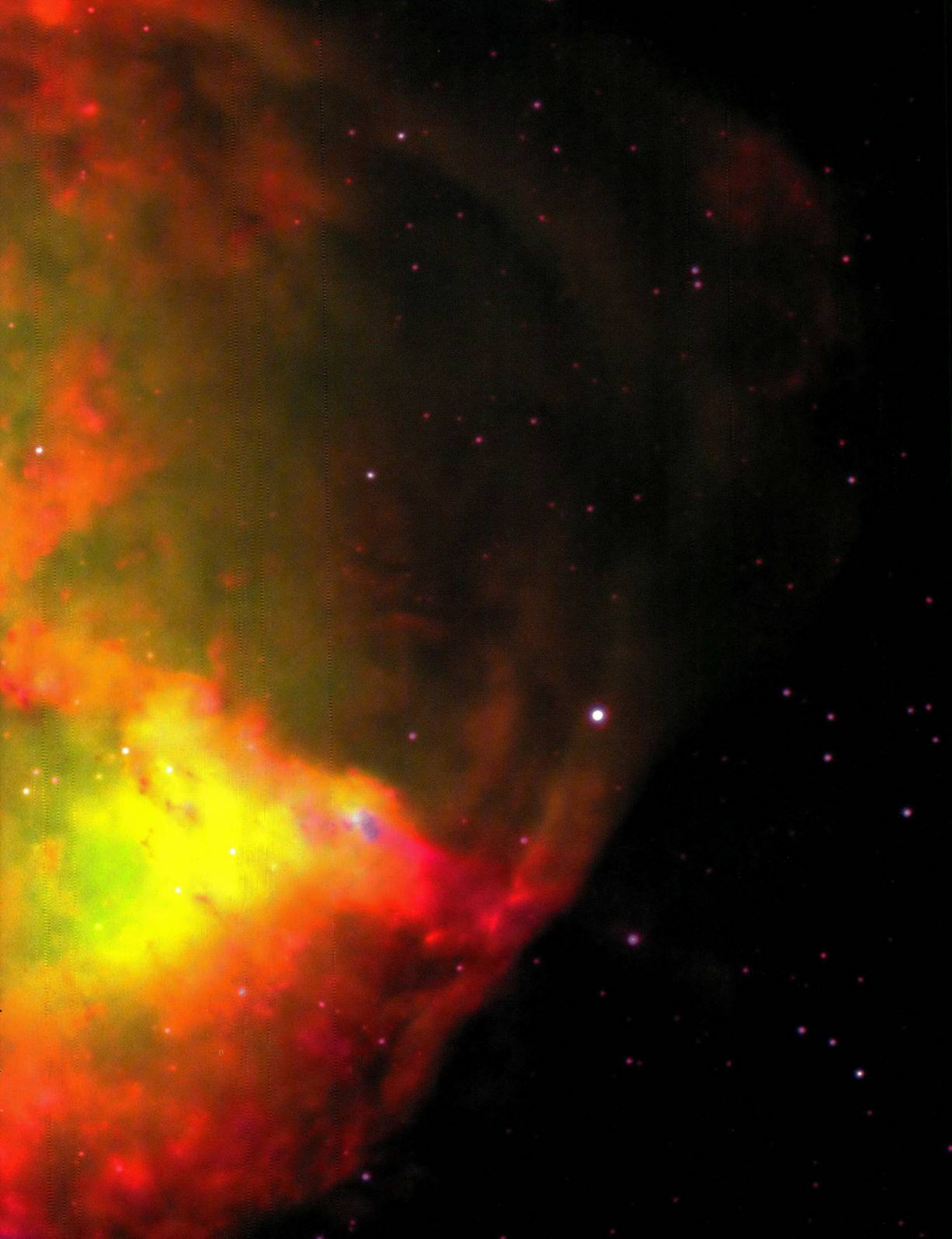

Leonids, craters, and pillars

Ever since the Leonid shower of last year, I had been awaiting this year's display. Although it did not turn out to be as spectacular as I had expected, the night was one of the best I've had since I became interested in astronomy two years ago. On the night of November 18th, I observed the nearly full Moon with my 6-inch reflector.

The location of the terminator, along with the Moon's tilt, allowed me to observe the rarely seen area of Mare Orientale. I even saw the double ring structure of the crater. At 4:30 A.M. I found the sky covered in dim clouds, which only allowed stars brighter than 2nd magnitude to be seen. I observed only 100 meteors in one hour, compared to 400 per hour last year. Even so, I saw several bolides and ion trails, along with the ISS, which passed right through the constellation Leo. Later that morning when the sky was brightening and the stars were fading, I noticed Venus in the east behind some dim clouds. A view through my telescope showed an amazing sight — the thin crescent of Venus, along with two beams coming out if its top and bottom. All of the amazing sights that night and morning made it one of the best times I have had under the stars.

BRIAN MONETTI
STIRLING, NEW JERSEY

Editor's note: See next month's Reader Gallery for additional photos and complete coverage of the 2002 Leonids.

A BRIGHT LEONID METEOR STREAKS over Quebec, Canada, in the early morning hours of November 19, 2002. Simon Filiatrault captured this 5-second exposure with a Sony DSC-F707 digital camera set at f/2. SIMON FILIATRAULT

Big Bang beliefs

I found Jim Sweitzer's five evidential exhibits ("Do You Believe in the Big Bang?" December 2002) a strong argument in support of the Big Bang theory. However, he also states that the Big Bang theory "is to an astronomer what evolution is to a biologist — and even more unpopular with the public." This statement lends little credibility to the argument. The Big Bang theory is objectively based science, supported with quantifiable and empirical data from such things as CMB radiation, "light elements," and Hubble Deep Field discoveries.

On the other hand, Darwin's evolutionary theory is 19th-century subjective science that becomes increasingly discreditable with each new scientific discovery. Comparing the two theories is like comparing apples and oranges.

The Big Bang theory is not an inviolable concept, but it is hard to argue with a theory whose evidence base grows, rather than shrinks, with each new scientific fact discovered.

DEAN POLL
ELY, MINNESOTA

I enjoyed Sweitzer's article; it provided commendable coverage of a complex subject in a short space. However, I found the wording of the title inappropriate, as it tends to reinforce the popular opinion that scientific theories are belief systems. While one may believe (or not believe) evidence supporting a scientific theory, there is a defined methodology for doing so, as the sidebar "'Just' a Theory" makes clear. Popular perception can be a strong function of the nuances of phrasing in the scientific domain.

RICHARD R. JOYCE
TUCSON, ARIZONA

Detecting exoplanets

I enjoyed "Unlocking New Worlds" in the November 2002 issue. However, the illustration of the Radial Velocity Method on page 50 is incorrect. The planet does not "yank" the star back and forth, but instead the planet and the star rotate around each other on opposite sides of their common center of gravity. Therefore, as the planet moves away from us, as shown, the star moves toward us and shows a blueshift, not a redshift as stated. In addition, the illustration of the Astrometry Method is misleading, as it shows the star shifted in the same direction as the planet. Since they both rotate around their common center of gravity, which is between them, they shift in opposite directions.

LEONARD DART, CLAREMONT COLLEGES
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We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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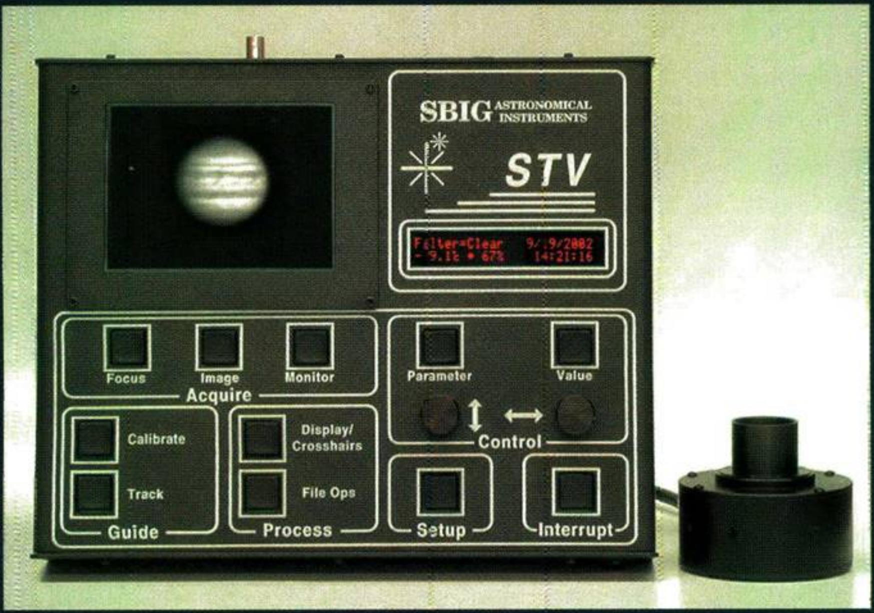
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BY WILLIAM SCHOMAKER

Jeff Hester

Arizona State University astronomer Jeff Hester knows Hubble. After all, he's employed the namesake telescope with remarkable success throughout the last decade to produce some of the most revealing and beautiful imagery that modern astronomy has to offer — most notably the now-famous Pillars of Creation in the Eagle Nebula.

Hester and his close collaborators continue to wow both the public and fellow astronomers alike with ongoing investigations of star-forming regions and supernova remnants, including a recent dynamical study of the wind from the pulsar in the Crab Nebula.

Is capturing the beauty of celestial objects a prerequisite for understanding them?

The aesthetic of astronomy is closely tied to the science of astronomy.

Our success as a species depends on our ability to discern patterns and relationships. Especially elegant patterns and relationships appeal to us so strongly that we find them pleasurable. That's the essence of "beauty." A splash of random color on a canvas is not thought of as beautiful, yet a da Vinci or a Monet captivates us. Appreciation of patterns and relationships is also the cornerstone of science. It is often the same elements that make an astronomical object "beautiful" that also hold the keys to understanding the object's physical nature.

How does it feel to have your work portrayed on television, the covers of news magazines, and postage stamps?

On balance, it is a lot of fun, so long as you don't take it too seriously. When my father was alive, he took great pleasure in showing things to people and saying, "Look what my kid did." I will admit that it's also a kick to see the starship *Enterprise* exploring what is quite clearly one of the columns in the Eagle Nebula. In the end, popular interest in my work has brought with it a lot of opportunities to represent science to the public. And that is something I care about a lot.

JEFF HESTER is celebrated among professional and amateur astronomers as the creator of memorable Hubble images. PHOTO BY TIM TRUMBLE/ASU

Do scientists have an obligation to popularize their work?

Absolutely. From a purely practical standpoint, John Q. Public pays for astronomy, and John Q. Public has a right to expect some visible return on his investment. And if we want to continue to enjoy the sort of public support that has fueled the major advances in astronomy for the last half century, we should take the trouble to communicate the more accessible of our results in a way the public can appreciate.

I doubt that schoolchildren 300 years from now will know what song topped the charts in 2003, or what political scandal filled the newspapers. But they will recognize ours as the time when humans first set foot off the world of our birth, and first reached out with our science and our technology and our sense of wonder to comprehend the universe beyond humanity's cradle.

Will you be sad to see the Hubble Space Telescope retired from service?

Very much so. I got personally involved with HST about five years before launch and later became part of the WFPC2 science team. Recovery of the scientific capability of the HST after the debacle of spherical aberration is one of the great dramas in the history of science. After nine years, I think we've come to take HST and its abilities for granted.

Any advice for today's aspiring astronomers?

Astronomy is a science filled with observations in need of understanding, and theories in need of testing. Many successful careers can develop from careful, thorough, and merciless confrontation of each with the other. A theory that does not incorporate the correct physics cannot be correct, even if it matches the data "to within astronomical accuracy." God and the devil both live in the details.

In the same vein, just because an idea has been published does not make that idea correct. Astronomy may be the oldest of sciences, but in some respects it is also one of the youngest. Beware the ad hoc explanation without testable predictions or independent corroboration.

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{ BOB BERMAN'S STRANGE UNIVERSE }

BY BOB BERMAN

Space emeralds

This month boasts a definite color scheme, and if St. Patrick's Day doesn't give it away then the first spring grass is clue enough: Green, of course. ☾

An *Astronomy* article about green a few years ago merely touched on cosmic greenery ("Seeing Red," July 1998). There's much more to it than meets the eye.

Despite surveys showing that people tend to choose blue as their favorite color, astronomers opt for green. Gather 'round the clover and see why.

Although the Sun emits a cornucopia of various wavelengths from radio waves to x rays, yellow-green is its strongest energy-output. That's also the place of the human eye's peak sensitivity. Our eyes were designed to see by sunlight. This green bias has important consequences both on Earth and in the heavens.

In dim twilight when all else has become murky and monochromatic, our retinas can still detect lime-colored objects at low levels. That's why more and more cities now have yellowish-green fire engines instead of the traditional red.

The illumination level of full moonlight (450,000 times dimmer than sunlight) lies on the boundary of exciting the eye's color sensors. Our retinas switch from their color-sensitive cells to the colorblind cells in light just about the brightness of a moonlit scene. Brighter light brings out full colors, while anything fainter (like a half Moon) makes the natural world a mixture of grays.

Curiously, full moonlight is just bright enough to stimulate our perception of one color. See for yourself within a day of the Full Moon (which, by chance, happens on the night of St. Patrick's Day, March 17/18). Grass will look green but any other color will appear gray. Green is the only color perceived in moonlight!

Although retinas can sense red, blue, and green light (constructing all other colors by combining inputs from these three alone) people's sensitivities vary. A good handheld spectroscope pointed to a bright cloud to observe the solar spectrum will let most people detect the broad H-α absorption line buried deep in the red. But some of us can't see that far into the spectrum's fringes. Individuality rules, so if you do see clear reds in moonlight, great — it's a rare talent.

In dim light when our eyes fully switch to scotopic colorblind mode, their peak retinal sensitivity shifts. Instead of yellow-green, our eyes' greatest perception is now in the green-blue part of the spectrum. This is the famous Purkinje shift. It concerns amateur astronomers more than other people because low light summons sky-watchers out to play.

Backyard astronomers already know that green is the only deep-space color perceivable through their telescopes (smaller than about 20 inches). While long-exposure nebula photos often display a carnival of reds and blues (most film emulsions are particularly sensitive to red light), the eye sees none of that. Instead, M42, M27, NGC 6543, and a myriad of others merely look pale green. It's as if there are twin parallel universes out there, one for photography, one for the eyepiece. And in a way, there are. The universe's most prevalent color in visual wavelengths is hydrogen's 6563 angstrom deep red, but our eyes more readily perceive oxygen's weaker emissions clustered in the low and mid 5000s, the greens.

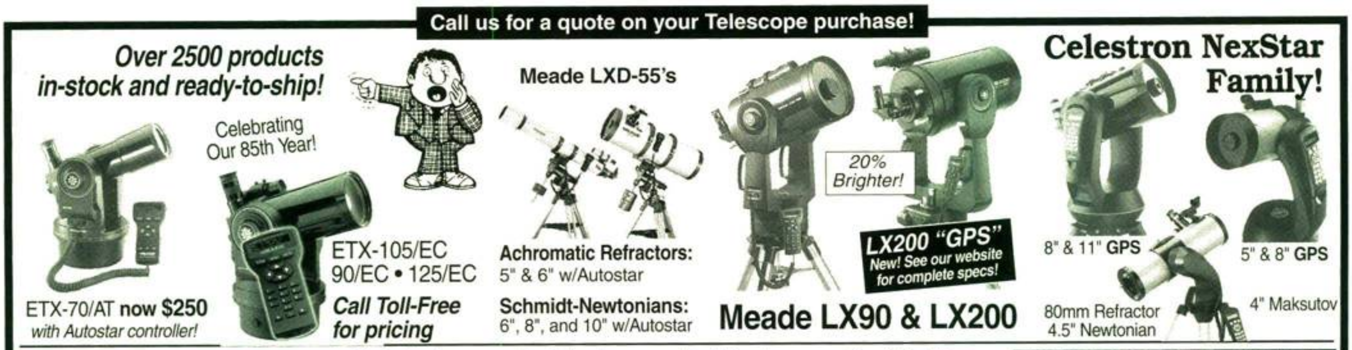
Since the universe's billions of galaxies typically peak in the green (like human vision), a pair of Arizona astronomers made a colossally embarrassing boo-boo last year that was duly reported by the mass media. The entire universe, they claimed, is actually green. While many of us promptly laughed at that ludicrous mistake, it took three months before those astronomers and the media issued a retraction and correction. Because other wavelengths are copiously mixed in as well, human vision sees the overall blend as white, just as sunlight appears white despite peaking in the green. In fact, contrary to assertions in older handbooks, there are no green stars whatsoever.

Our eyes' insensitivity to certain colors often springs up in nature. For example, the real color of the daytime sky is violet! The reason: Air scatters more violet light than any other tint. But violet is so poorly perceived by our eyes that blue overwhelms it. Some animals do see the violet sky.

Planetary nebulae and meteors — the night is filled with green things that emit strongly in other unseen colors. If we glimpse the Northern Lights (and March is statistically the month of maximal displays), it too will likely appear green, but this time it's no optical illusion. The 5577 doubly ionized oxygen line is usually the dominant emission of the aurora borealis.

March's emerging plants and leaves look green for an entirely different reason. Grass and plants prefer red light, and can snack on blue as well, but decisively reflect green. Plants hate green. They look green because we're seeing the rejected wavelengths!

Although we don't particularly associate cloudy Ireland with astronomy, Saint Patrick would be pleased if he could scan the cosmos. For a variety of fascinating reasons, the emerald of his island is the most widely seen color on Earth — and across the universe.



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Dew shield 670	**20**
Dew shield 673	**25**
Dew shield 675	**28**
Dew shield 678	**30**
Epoch 2000 CD	**100**
Filter set #3200	**40**
Filter set-1, 2, or 3	**50**
Finder #825	**52**
Finder #827	**52**
Focuser #1244	**124**
Focuser #1247	**124**
Flip-mirror #644	**150**
Flip-mirror #647	**250**

Meade Accy's:	
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Focal reducer f:3.3	**150**
Lenshood 7-12"	**call**
Nebula 908 B	**80**
Nebula 908 N	**90**
Nebula 908 O-III ...	**100**
Nebula 911 B	**100**
Nebula 911 N	**120**
Nebula 911 O-III ...	**150**
Off-axis guider	**87**
Prism 45° #932	**50**
Prism 45° #933	**50**
Pictor 416XTE	**1999**
Piggy brkt 7-12"	**call**
Prism 2" 90° UHTC	**105**
Skylight/seal	**50**
Tripod #880	**32**
Tripod #881	**62**
Tripod #882	**100**

Meade Accy's:	
Tripod #884 w/cs ...	**$200**
T-adapter #64	**37**
T-adapter #64ST ...	**20**
Tele ext-variable	**40**
T-adapt: SCT	**30**
T-adapt: vari-proj ...	**40**
T-adapt: 1.25"	**30**
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Vari pol 905	**50**
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Wedge 8" LX200 ..	**148**
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11" full aperture	**179**
12" full aperture	**189**

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Radian-60°	
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16mm Type5 ...	**320**
17mm Type4 ...	**385**
22mm Type4 ...	**460**
26mm Type5 ...	**580**
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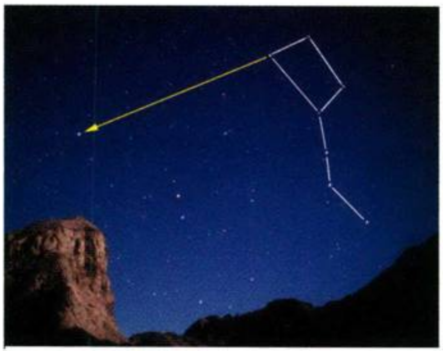
This way up

You're thumbing through your favorite magazine (*Astronomy*, of course), when you come across the statement: "Saturn shines high in the southern sky after sunset this month." Do you feel frustrated and lost because you don't know where "south" is and you don't have a compass? Fear not. Here are three astronomical ways to find your bearings.

The first works only on the equinoxes — the first day of spring and the first day of autumn. On these days (the first day of spring falls on the 20th of this month), watch where the Sun peeks above the horizon to find east, or where it sets to locate west.

A second way, employed by aboriginal tribes, also uses the Sun, but works at any time of the year. Around midday, place a stick in the ground so it points straight up. Place a marker (a stone or small twig) at the tip of the stick's shadow. As Earth rotates and the Sun drifts across the sky, your stick's shadow will move. After 15 to 20 minutes, place a second marker at the new location of the shadow's tip. A line connecting these markers points east-west. The first marker is on the west end of the line; the second is on the east.

If all else fails, try the time-honored method used by Boy and Girl Scouts everywhere — at least in the Northern Hemisphere. On any clear night, a good scout knows how to locate due north. Start at the Big Dipper. Follow the line up from two stars in the bowl, Dubhe and Merak, until you see Polaris, the North Star. Many beginners who see Polaris for the first time are surprised this famous star isn't any brighter than the stars in the Big Dipper. They assume that, because of its importance, Polaris must be the brightest star in the nighttime sky. (If you were here last month, you know that title goes to Sirius.) If you've been "lost in space," let the Sun and the North Star guide you out of the cosmic forest.



THE NORTH STAR is easy to find once you locate the Big Dipper. The outermost two stars in the bowl, Dubhe (left) and Merak (right), point right to it. JERRY SCHAD

Now that you know where south is, you can concentrate on your favorite magazine's message — indeed, Saturn does shine high in the southern sky after sunset this month. Located prominently in a loop of stars known as the Winter Hexagon, the Ringed Planet can be spotted above the constellation Orion (see the all-sky map in the center spread).

Saturn isn't the only planet in the evening sky. Farther east (to the left) is mighty Jupiter, shining brighter than any of the nighttime stars.

You may think that planet-viewing without an optical aid is pointless, but wait until you see the Moon lying oh-so-close to a bright planet. On the evenings of the 10th and 11th, a First Quarter Moon (half Moon, to you poets) flirts with Saturn, while a fatter waxing gibbous Moon pays a visit to Jupiter on the evening of the 14th.

If you want to see close-up details, you will need some kind of optical aid. Standard binoculars won't help much, although you might glimpse one or two of Jupiter's moons next to the planet's tiny disk. A telescope offers more clarity. The good news is the scope doesn't have to be an expensive, gazillion-power model. A small backyard telescope magnifying just 30 to 50 times (30x to 50x) will do the trick. With that magnification, you can actually see Saturn's legendary rings.

Train a telescope on Jupiter and you'll see a pale yellow disk slightly wider than it is tall, crossed by several dark bands of clouds. The bright "stars" strung out next to Jupiter are the satellites Galileo discovered four centuries ago. Four are usually visible; if you see fewer, the missing moon may be hiding behind — or camouflaged in front of — the giant planet. Because we view their orbits edge-on, the moons seem to drift slowly from one side of Jupiter to the other. Make nightly observations to follow their cosmic dance.

Have you ever seen an asteroid, or minor planet? During the first week of March, you'll have a great opportunity to capture the brightest of the asteroids, Vesta, as it passes through the constellation Virgo. At about 10 P.M., look for the Big Dipper. The handle forms an arc that passes through the bright star Arcturus and Virgo's brightest star, Spica, which lies low in the southeast sky. West (right) of Spica lie three prominent stars that form an upright row. Vesta is between the top two. Unless you have keen eyesight and live in a dark-sky environment, you probably won't see anything without binoculars or a telescope. But if you think you've spotted Vesta, go out a few nights later and look again. If the "star" has moved, you've notched a major minor planet, a feat that, according to legend, not even Copernicus could do. Find out more next month. Clear Skies!

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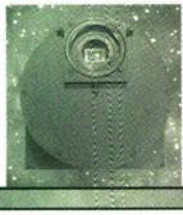

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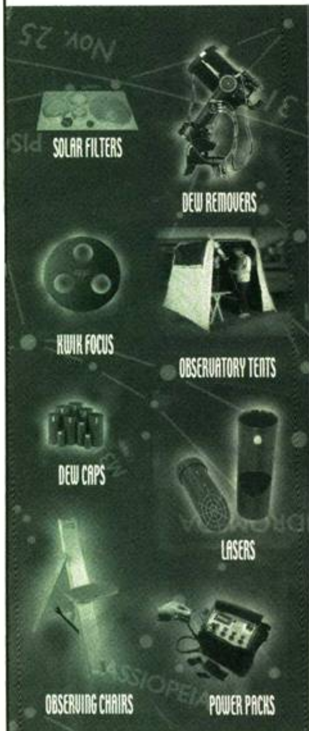

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Your wait is over. You've been asking us for a complete selection of our top-of-the-line Schmidt-Cassegrains mounted on a beefy computerized German Equatorial mount. We proudly announce the CGE Series — CGE 1400-14", CGE 1100-11", CGE 925-9.25", and CGE 800-8".

SCT OTA and CGE Computerized Mount — Portability and Stability In A Complete System. All CGE's can be quickly disassembled into easy to handle transportable components — even the CGE 1400! Recognized for superior stability, German Equatorial mounts eliminate the tuning fork like vibration associated with fork mounted telescopes. The new CGE's are ideal for viewing objects in every part of the sky – even in the North where fork mounts have difficulty pointing.

Easy to polar align – German Equatorial mounts are the choice of the best astrophotographers.

Easy to counter balance – In both RA and Dec, for smooth photographic quality tracking.

◀ CGE 1400
CGE 1100 ▶

The CGE Mount is made of CNC machined aluminum and stainless steel and features the NexStar® control system.

Drive Base Features:

- Autoguide port
- PC port
- 3 Accessory Ports
- Real time clock – maintains time even when powered down
- Strain relief power cord cable protection
- Backlit power switch

Drive System:

- U.S. manufactured Pittman 12V DC servo motors
- U.S. manufactured Berg bronze drive gear mated with stainless steel worm shafts
- 4 point RA clutch system for no slip pointing precision

Tripod Features:

- Dual Leg Support
- Center leg brace provides outward preload
- Lower leg brace provides inward preload
- Extendable powder-coated carbon steel legs

OPTICS	CGE 800	CGE 925	CGE 1100	CGE 1400
Focal length	2032mm; f/10	2350mm; f/10	2800mm; f/10	3910mm; f/11
Secondary Obstruction	2.7"	3.35"	3.75"	4.5"
Resolution (Rayleigh)	.68 arcseconds	.59 arcseconds	.50 arcseconds	.39 arcseconds
Coatings	StarBright®	StarBright®	StarBright®	StarBright®
Optical Tube	Carbon Fiber	Aluminum	Carbon Fiber	Aluminum
Fastar Compatible	Yes; f/1.95	No	Yes; f/2	Yes; f/2.1

STD. ACCESSORIES	CGE 800	CGE 925	CGE 1100	CGE 1400
Eyepiece	25mm Plössl	25mm Plössl	40mm Plössl	2" 40mm Barrel
Star Diagonal	Prism Diagonal	Prism Diagonal	Prism Diagonal	2" Mirror Diag. with $1^{1/4}$" Adapter
Finderscope	6x30	6x30	9x50	9x50
Power Supply	Car Battery Adapter	Car Battery Adapter	Car Battery Adapter	Car Battery Adapter
Counter Weights	1-11lb.	1-25lb.	1-25lb.	2-25lb.

PRICING

CGE Computerized Mount (#91524):
$2999 + $95 Shipping & Handling
CGE 800 (#11058):
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CGE 925 (#11059):
$3799 + $145 Shipping & Handling
CGE 1100 (#11061):
$4149 + $245 Shipping & Handling
CGE 1400 (#11063):
$5799 + $295 Shipping & Handling

Optional Accessories:

- 12V DC Rechargeable Power Supply (#18774)
- 2"-70º Apparent Field, Axiom Eyepieces
- Reducer Corrector; f/6.3 (#94175)
- CN16 GPS Accessory (#93963)

Specifications

Software

40,000 + Objects
400 User defined objects
Hibernate – Maintains alignment even while powered down
Polar alignment routines for Northern and Southern hemisphere
Filter limits – Displays only objects above the horizon
Permanent programmable PEC – Corrects periodic tracking errors inherent in all worm drives
Smooth ramping of slew motors to reduce wear on drive train

Electronics

Home sensors on RA and Dec axes
Real time clock
Fail safe slew limit switches in RA
12V DC Servo Motors with integrated optical encoders, 256CPR used in quadrature
Encoder resolution: .11 arcseconds

Mechanics

CNC machined aluminum and stainless steel components

RA axis

- 1" solid ground stainless steel shaft
- Two Preloaded .9835" I.D. x 2.047" O.D. tapered roller bearing
- One 4.724" O.D. x 3.543" I.D. thrust bearing
- 180 tooth, 5.625" diameter enveloping bronze gear preloaded to maintain gear mesh while clutch tension varies, manufactured to AGMA 10 quality.
- .4375" diameter precision 303 stainless steel worm, manufactured to AGMA 10 quality
- 4 point RA clutch system pre-loading a 4.65" stainless steel disk for no-slip drive and pointing precision

Declination axis

- 1" solid ground stainless steel shaft
- Two Pre-loaded .9835" I.D. x 2.047" O.D. tapered roller bearings
- One 3.250" O.D. x 2.500" I.D. thrust bearing
- 180 tooth, 5.625" diameter non-enveloping bronze gear preloaded to maintain gear mesh while clutch tension varies, manufactured to AGMA 10 quality.
- .4375" diameter precision 303 stainless steel worm, manufactured to AGMA 10 quality
- 2 point Dec clutch system pre-loading a 4.65" stainless steel disk for no-slip drive and pointing precision

Latitude Range: 10º to 60º
CGE Maximum Payload: 65 lbs.

Tripod

- Tripod height: 36" to 50"
- Leg material: cold rolled carbon steel
- Upper leg diameter: 2.75"
- Lower leg diameter: 2.375"

CELESTRON
CGE 925►
CGE 800►

Pittman 12V DC servo motors; Berg bronze drive gears are mated with stainless steel worm shafts for smooth operation.

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"We ran through the alignment procedure during evening twilight and observed throughout the entire night without missing a beat...and every object that we commanded the scope to point at ended up in the field of a low-power eyepiece."

"The optics in the NexStar loaned to us were some of the finest I can recall in a Schmidt-Cassegrain, but if anything the optics in the scope we purchased at random were even better."

–Dennis di Cicco
"The NexStar 11 GPS: Beauty and Brains"
Sky and Telescope
February 2002

A telescope that combines the design features, engineering, performance, and value of the NexStar® 11GPS doesn't come out of the *Blue*.

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NexStar® 11GPS
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Includes Standard Heavy-Duty Adjustable Tripod

At Celestron, we know that the whole is greater than the sum of all of its parts. That's why we design, engineer, and manufacture the NexStar 11GPS telescope from the beginning with features and performance that add up to a whole lot more telescope than the competitor's 8", 10" and 12" GPS telescopes — ***and a better value.***

Here's why: Compare the design features and construction of the NexStar 11GPS (as well as the NexStar 8GPS) to the competitor's 12", 10", and 8" GPS telescopes. Every component of the NexStar 11GPS, from its rugged integrated drive base and fork arm design to the unique carbon fiber optical tube assembly has been designed specifically for this model NexStar telescope. Only Celestron matches and meticulously hand-figures each individual telescope optical system.

Understanding Resolution.

Do coatings affect resolution? No! When comparing telescopes, it's extremely important to clearly understand the relationship between coatings and resolution. ***Fact: Resolution is a function of aperture.*** ***Coatings only affect light transmission***. It is a function of aperture or diameter of the objective lens. Rayleigh's Criterion defines resolution as: $\theta=1.22*\lambda/D$, where λ is the wavelength of light, D is the diameter of the objective lens, and θ is the resolution in radians. Image brightness is a function of aperture, focal ratio, and system's light transmission efficiency. ***StarBright® coatings have been standard on all of our Schmidt-Cassegrain telescopes since 1983 AT NO ADDITIONAL COST***. For primary and secondary mirrors, StarBright coating is a precise multilayer application of Al, SiO_2, TiO_2, and then another layer of SiO_2 — all to maximize reflectivity. On the corrector lens we apply precise layers of MgF_2 to both surfaces to maximize transmission.

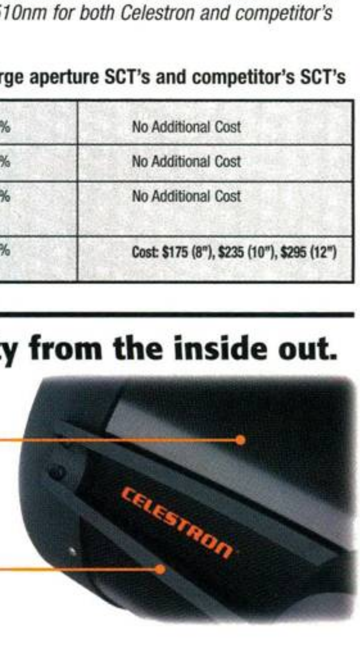
The dark-adapted (scotopic) eye's peak sensitivity is at 510nm. The sensitivity drops off dramatically on either side of 510nm. In fact, as the wavelength approaches 400nm, the eye's sensitivity goes to almost 0%. The same is true as the wavelength goes to 600nm. Celestron's StarBright® Coatings are designed to peak at 510nm, the peak sensitivity of the scotopic eye. Celestron offers these coatings at no additional cost to the consumer. The chart below shows the transmission at 510nm for both Celestron and competitor's large aperture SCT telescopes.

Transmission at 510nm for all Celestron large aperture SCT's and competitor's SCT's

NexStar 8"	87%	No Additional Cost
NexStar 9.25", 11", 14"	85%	No Additional Cost
Competitor's Standard Coatings - all SCT's	77%	No Additional Cost
Competitor's UHTC	86%	**Cost: $175 (8"), $235 (10"), $295 (12")**

Competitive information obtained from December, 2002 issue of *Sky and Telescope*.

NexStar 11GPS. Quality from the inside out.



Carbon Fiber Tube — ***Strong and lightweight with 1/4 of the thermal expansion of an aluminum tube. Scratch and dent resistant.***

Optical Tube Assembly Outer Rails — ***An outer rail on each side of the optical tube provides rigid, flex-free movement. Mounting tolerance allows cell to contract and expand.***

NexStar quality and reliability. Designed in. Not added on.

COMPARISON OF DESIGN FEATURES

This chart compares the significant design and engineering features of the NexStar 11GPS with competitor's 10" and 12" GPS telescopes.*

Feature/Specification	NexStar 11GPS	Competitor's 10"	Competitor's 12"
Mirror Coatings	StarBright*; 5-step multilayer	Standard; (Enhanced Coatings $235)	Standard; (Enhanced Coatings $295)
Fork Arm	Dual fork tine cast aluminum with integrated hand control receptacle. Fork arms are long enough to permit optical tube to swing through	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket.	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket; fork arms not long enough to allow optical tube to swing through
Leveling Technique	Internal switch - levels the tube to the mount to the accuracy of 1 arcminute; Usable for both Alt/Az and equatorial	Ground level switch; only useful for Alt/Az	Ground level switch; only useful for Alt/Az
Cord Management	Internal slip ring design. Power is mounted to non-rotating part of drive base. Accessory ports rotate with top of drive base	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling
Carrying Handles	Ergonomically designed for ease of lifting	Attached to front of fork arms	Attached to front and back of fork arms
Motors	Pittman mfg. in U.S.A.;12V DC Servo; quiet	Unknown; very noisy	Unknown; very noisy
Gears	Berg mfg. in U.S.A.; 5.625" precision bronze gears on both axes; 180-tooth; mated with stainless steel worm shaft	5.75" aluminum gears on both axes	5.75" aluminum gears on both axes
Bearings	9.5" roller azimuth bearing	4" dia. polar bearings	4" dia. polar bearings
Focusing Mechanism	Two (2) preloaded ball bearings	Bushing and washer	Bushing and washer
Optical Tube	Carbon Fiber; reduces thermal expansion; 4x less than aluminum	Aluminum	Aluminum
Fastar Compatible	Yes	No	No
Weight of Telescope	63 lbs.	62 lbs	75 lbs
GoTo Precision	1.5 arcminutes	2 arcminutes	2 arcminutes
Boot-up Time	1-1.5 sec.	20-25 sec.	20-25 sec.
GPS Alignment Time	2.5 min.	More than 4.5 min.	More than 4.5 min.
Quick Align	Yes	No	No
Database Filter Limits	Automatic filter limits for named objects list	No database filter limits for custom object lists	No database filter limits for custom object lists
Price**	**$2,999 + $125 S&H = $3,124**	**$2,495 + $145 S&H + $235 for Enhanced coatings = $2,875**	**$2,995 + $215 S&H + $295 for Enhanced coatings = $3,505**

How you can tell wrong from right.

Celestron strongly believes that the only way to design and manufacture our NexStar GPS telescopes is the ***right way***. The right way means understanding what expectations our customers have when they make an investment in our products, and designing and manufacturing telescopes that meet or exceed their expectations. That means paying attention to details and not cutting corners. Compare the following examples of why we believe that we have designed the NexStar 8GPS and 11GPS the right way and what we believe is wrong with the design of the competitor's GPS telescopes. Consult the chart to the left for an additional comparison.

Their Way:

- The competitor's GPS antenna is partially obstructed by the finderscope.
- When the base rotates, cables can easily wrap around the fork arms and become entangled.
- Carrying handles are poorly designed and located making it difficult to lift the telescope.
- Boot-up time can take as much as 20-25 sec.
- Hand control displays objects below the horizon.
- Motors and gearbox are noisy.
- The competitor's 10", and 12" drive base is undersized.
- The OTA (Optical Tube Assembly) on the competitor's 12" will not swing through and clear the drive base; the fork arms have spacers to attach to the base.
- The complete optical system is not hand-figured.
- The hand control is attached to a bracket with the cable hanging loose.
- Enhanced optical coatings cost extra
- Focus mechanism uses bushings intead of ball bearings.

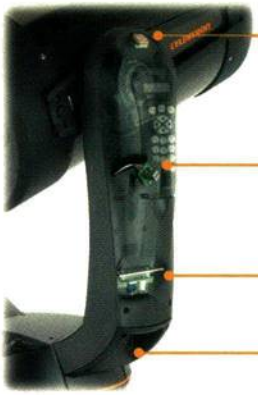
Our Way:

- Celestron's GPS antenna is not obstructed by the finderscope.
- Celestron's drive base design eliminates any potential for cord/cable wrap.
- Carrying handles are integrated into fork arms to make lifting and transporting easier.
- Boot-up and alignment are fast and easy.
- Hand control has many advanced features and is user-friendly; only shows objects above the horizon.
- High quality precision gearing ensures quiet, precise operation.
- Large diameter drive base and bearing track provides maximum stability. Especially important when equatorially mounted.
- Carbon fiber tube minimizes thermal expansion/contraction; important for astrophotography or CCD imaging.
- Mirror shift minimized through use of precision bearings.

---

* Version Tested: 1.0b Telescope Serial #01039 All comparative information obtained from User Manual for this model.

**Prices obtained from December, 2002 issue of *Sky & Telescope*
Set-up Information: Starting Position: Alt.= -90 and Az =0
Date: 09.18.02 Time: 8:00 PM (no daylight savings) Long: 118 West Lat: 34 North



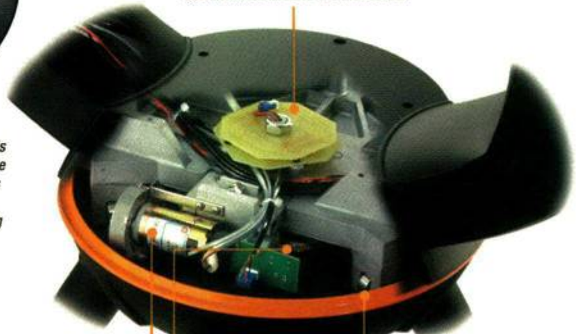
16-channel GPS — ***Interference free. Finderscope is positioned away from GPS antenna. Pinpoints your exact location on Earth with an unobstructed view.***

Upgraded hand control and software features — ***40,000 object database; new features include compass calibration, polar alignment routine, EQ AutoAlign, database filter limits, hibernate, Auto north and level, wedge align algorithm, Quick Align, user-defined slew limits.***

Electronic compass — ***Finds true North when used in conjunction with NexStar software.***

Ergonomically designed fork arm with integral handles — ***Integrated handles in fork arms designed for ease of carrying and safe and easy setup and transportation.***

Auxiliary Ports — ***The NexStar's auxiliary ports are located on the top of the base which rotates as the telescope turns preventing accessory cables from wrapping around fork arms.***

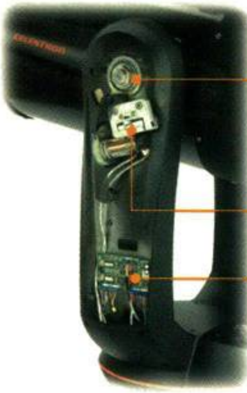


Internal Slip Ring — ***The NexStar's power cables will never wrap and telescope accessory cables will not get wrapped around the telescope.***

Drive Motors — ***Made in the U.S.A., Pittman Lo-Cog™ brush commutated DC motors offer smooth, quiet operation and long life. The motor armatures are skewed to minimize cogging which is required for low speed tracking. Windings are resin impregnated for greater reliability in incremental motion application.***

Precision bronze gear — ***32 pitch, 5.625" pitch diameter, 180-tooth bronze gear. Manufactured in the U.S.A. by W.M. Berg, Inc. Manufactured to AGMA Quality Class 10 standard which minimizes total composite error and backlash.***

Unique roller bearing design — ***Base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounting for imaging.***



Bearing and shaft — ***Heavy-duty preloaded tapered roller bearing on both axes.***

Worm shaft — ***Stainless steel worm shaft has .4375 pitch diameter and is preloaded with two ball bearings. The worm is made from a single piece of steel to minimize run-out, which is the source of periodic error.***

Heavy-duty aluminum spring loaded worm block — ***On both axes; minimizes backlash.***

Motor board — ***Each axis is controlled by its own 8-bit microcontroller.***

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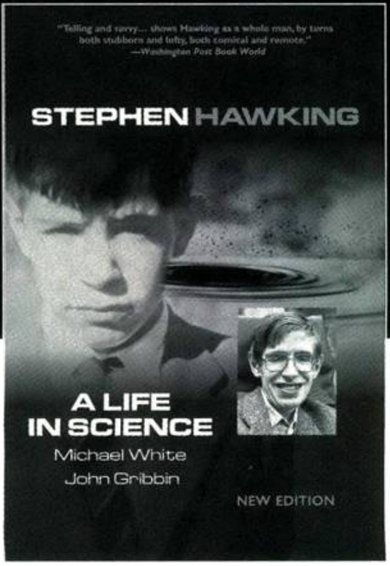
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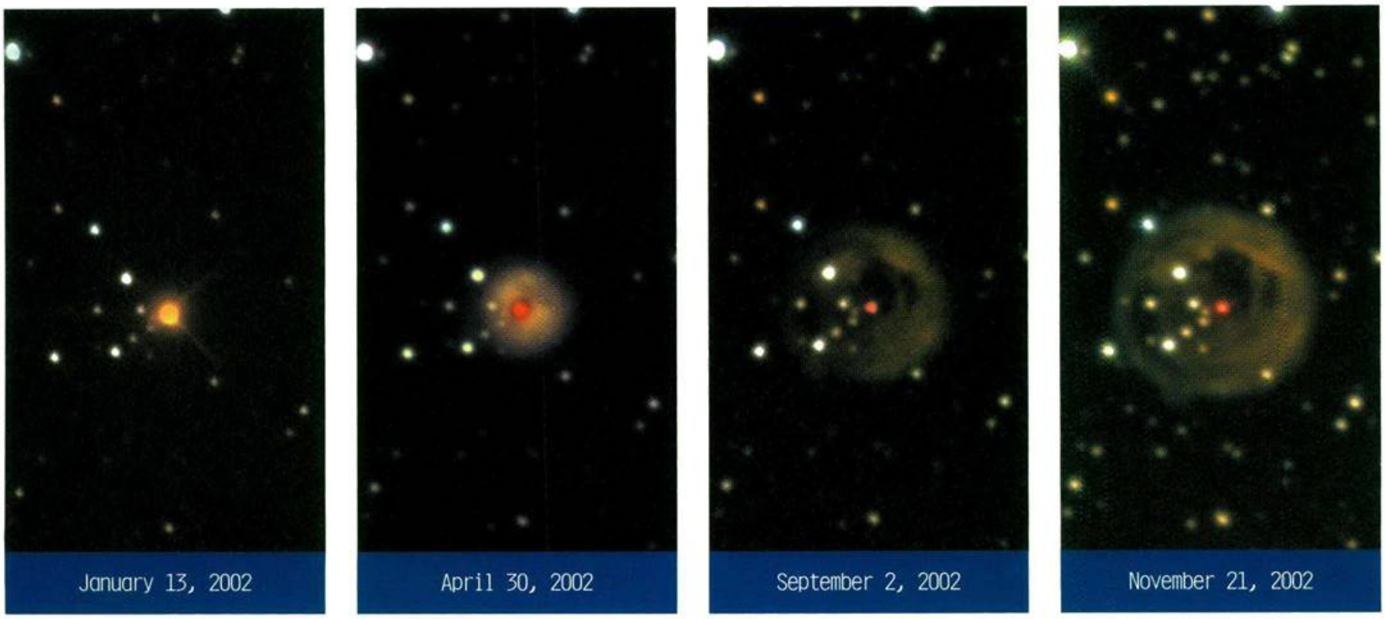
news 03

Read all about it: Eruptions on Io, Mars exploration plans, black hole binaries, extrasolar planet measurements, and nebulae in the Large Magellanic Cloud.



January 13, 2002

April 30, 2002

September 2, 2002

November 21, 2002

EXPANDING LIGHT ECHOES illuminate successively more distant spheres of the dust and gas cloud that surrounds V838 Mon. These images were taken with the USNO Flagstaff Station 1-meter Ritchey-Chrétien telescope, with a SITe/Tektronix 1024 by 1024 CCD. ARNE HENDEN AND AL KELLY

SUPERNOVAE

Nova of a new color: V838 Mon

An anonymous magnitude 15.6 star in the constellation Monoceros the Unicorn flared into notoriety on January 6, 2001. Rising in two steps to a maximum magnitude of 6.5, this new nova may represent a previously unknown type of variable star.

In serendipitous observations before the outburst, a main sequence-like star was observed coincident with an IRAS source at the location of the nova. The IRAS infrared detection indicates that a cloud of warm dust and gas from stellar winds surrounds the visible star. It is unclear if this star is isolated or if it has a low-mass, cool white dwarf companion.

If the star is isolated, this nova may represent a never-before-observed stellar evolutionary transition. If it is a binary, the outburst may be evidence of surface-wide thermonuclear explosions on an invisible white dwarf companion star. The correct classification will come from ongoing observational campaigns.

As photons radiate from the star in all directions, they are reflected off dust grains and gas. Because it takes light reflecting off various parts of the nebula different amounts of time to reach us, we see echoes of light that create complex, ever-expanding rings of visible material. — **PAMELA L. GAY**

31 **The age of O'Keefe**

34 **Optically visible radio jets**

35 **Canada sees Mars in future**

36 **Big measurement, little planet**

NASA has selected several concepts for further study in its low-cost Mars Scout program. Aimed for launch in 2008, these simple but scientifically valuable probes would supplement the larger and more expensive "mainline" Mars missions.

SOLAR SYSTEM

Io erupts

When Jupiter's moon Io spewed the largest volcanic eruption ever seen, one telescope on Earth was ready for it.

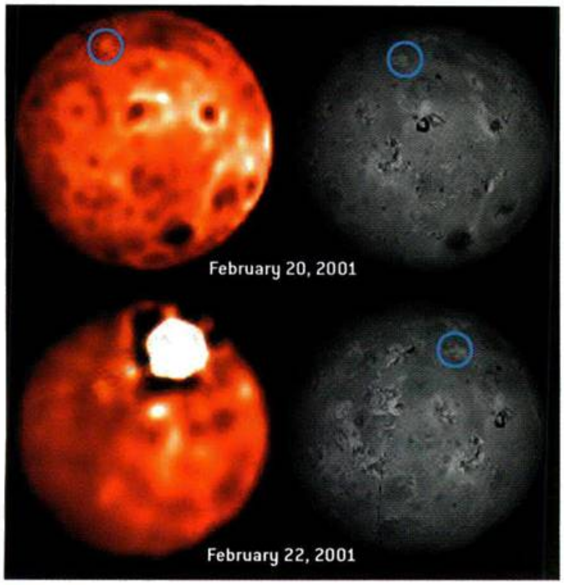
In February 2001, planetary scientists were using the 10-meter Keck II telescope in Hawaii to study Io at infrared wavelengths. All was quiet on February 20, but just two days later a very bright eruption appeared in the northern hemisphere near a feature called Surt, which unleashed a large outburst in 1979.

"It is clear that this eruption is the most energetic ever seen, both on Io and on Earth," says team leader Franck Marchis of the University of California, Berkeley. "The Surt eruption appears to cover an area of 1,900 square kilometers, which is larger than the city of Los Angeles," Marchis adds. This is larger than any erruption recorded on Earth.

Researchers also determined that Io's erupting lava had a temperature of 1500 kelvins, similar to terrestrial lava temperatures. This suggests Io's lava is silicate-rich like Earth's.

Keck II resolved Io and its eruption using an adaptive optics system that removes atmospheric blurring. Its resolution is often better than that of the Near Infrared Mapping Spectrometer on the Galileo spacecraft.

— **VANESSA THOMAS**



NEW LAVA spreads after volcanic eruption on Jupiter's moon Io. The infrared images (left) are from Keck II, while the visible-light images (right) were taken by Galileo. KECK/GALILEO

OBSERVATORY NEWS

Hilo groundbreaking

Hilo, Hawaii, is the new home of a state-of-the-art observers' facility. On October 28, 2002, Hawaii officials joined astronomers to break ground on the site of the SMA Hilo Operations Facility.

THE OBSERVERS' FACILITY on Hilo, Hawaii, will be a home away from home for submillimeter observers. ESO

The Hilo facility will support the Submillimeter Array (SMA) on nearby Mauna Kea. The SMA is the world's first imaging array to operate on submillimeter wavelengths. The SMA will penetrate the dusty, obscure regions of space and reveal to astronomers new information about star development locally and at the distant edges of the universe.

The facility provides offices for astronomers, engineers, and technicians, and includes workshops and laboratory space. Completion is scheduled for 2003. — MATT QUANDT

STARS

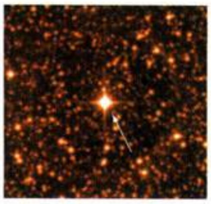
Sizing up little stars

Early work by the Very Large Telescope Interferometer (VLTI) has helped astronomers measure the size of Proxima Centauri and three other very low-mass stars for the first time.

Just 4.2 light-years away, Proxima Centauri is the Sun's closest stellar neighbor. Astronomers knew this faint M-dwarf star is about one-seventh as massive as our Sun, and now, a group of astronomers has determined that Proxima Centauri is about one-seventh the diameter of the Sun, or about 1.5 times the size of Jupiter. Observations were made during a test run that linked two of VLTI's 8.2-meter telescopes for the first time. These telescopes have adaptive optics that can remove atmospheric blurring.

The team accurately calculated the diameters of three other M-dwarf stars as well.

"The measured sizes agree well with theoretical predictions, based on numerical models of planets and low-mass stars," says Geneva Observatory team member Didier Queloz. — **V. T.**



PROXIMA CENTAURI is just 1.5 times larger than Jupiter. ESO/STScI/DSS

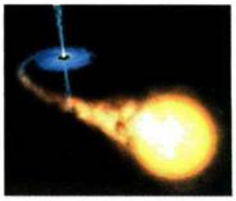
BLACK HOLES

Running from the scene

Supernova explosions are often asymmetrical, and conservation of momentum predicts that they should eject black holes in the fiery explosions that punctuate their birth. A group of astronomers working with the European Space Agency and the Space Telescope Science Institute has now mapped the motion of a black hole binary system and determined that its velocity likely resulted from this type of formation.

The black hole binary system GRO J1655–40 is streaking out of the galactic bulge at 250,000 miles (400,000 km) per hour.

"This is the first black hole found to be moving fast through the plane of our galaxy," says Felix Mirabel of the French Atomic Energy Commission. "This discovery is exciting because it shows the link of a black hole to a supernova." — **P. L. G.**



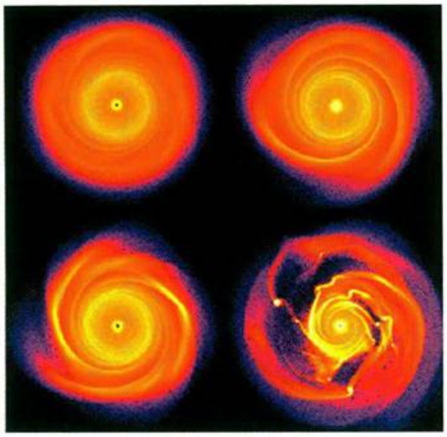
A BLACK HOLE BINARY named GRO J1655-40 shoots through the galactic plane at a quarter-million miles per hour.

ESA, NASA AND FELIX MIRABEL

EXTRASOLAR PLANETS

Fast formation

In typical solar system formation models, a proto-planetary disk of material surrounds a young star, and over more than a million years the disk forms planets. Unfortunately, in reality this doesn't work. Stars like the Sun form in stellar nurseries like the Orion Nebula, where ultraviolet radiation abates disks in much less than a million years.



PROTOPLANETARY DISKS fragment and begin to form planets in just a few rotations. This model disk is about 20 AU in radius, and the density increases from blue through magenta. SCIENCE, MAYER ET AL

"If a gas giant planet can't form quickly, it probably won't form at all," says Thomas R. Quinn, a University of Washington astrophysicist.

Using complex computer models, a North American team of astronomers has shown that proto-planetary disks actually begin to break apart after just a few rotations. Initially, the disks form arm-like structures, and these fragment to form planets. Within 350 years, planets with masses similar to Jupiter can form.

In addition to explaining planet formation, these models also explain why Jupiter and Saturn have gaseous envelopes, while Uranus and Neptune don't: They were affected by the same ultraviolet radiation that destroyed the disk. Over the eons, the solar system has orbited away from its stellar nursery, and we are now safely far away. — **P. L. G.**

NASA under O'Keefe

NASA's success in assembling core sections of the International Space Station and operating it for more than two years is a remarkable space engineering achievement. This success contrasts with an equally spectacular failure in program management and budgeting on Earth. In 2001, shocked accountants discovered billions of dollars in overlooked expenses and unfunded commitments. "Nobody has any confidence that we know how much [the space station] will cost," complained John Marburger III, President Bush's science advisor.

In December 2001, President Bush nominated former Secretary of the Navy Sean O'Keefe to take the helm as Administrator of NASA. Writing for the Internet newsletter *Spacelift*, space analyst Frank Sietzen pointed out that O'Keefe "has a reputation as a person who fixes troubled government projects — one way or the other."

O'Keefe will not let political or diplomatic issues be the prime motivators for program decisions. "We need to have the science goals drive the planning," O'Keefe has said. He called for defining "a series of objectives of what we hope to get, in terms of the science and technology." This is his criterion for making program decisions and the philosophy behind his statements about the need for better electrical power and propulsion systems for space vehicles. "We have been in the 'age of sail' for a long time," he recently mused, in a naval metaphor. "It's time to enter the 'age of steam' and fly faster." This has led to his push for wider use of nuclear power in space.

THE INTERNATIONAL SPACE STATION will help advance human on-orbit research. **INSET: SEAN O'KEEFE,** NASA's new administrator, follows after Dan Goldin's ten-year tenure. NASA

He also is an advocate of the space station program. "I think it has tremendous capability," he said, and "if we didn't have such a capability, then we would have to create it." As for enlarging the station to provide room for the additional planned European and Japanese laboratories, O'Keefe agreed that it's important "to expand it to its fullest potential." He added: "There is no intent whatsoever to walk away from our international commitments."

O'Keefe and his new management team spent their first year determining the real state of NASA "flagship programs." They also determined the true costs of future projects and defined what strategic goals should motivate projects.

At the end of 2002, O'Keefe announced a sweeping strategy for consolidation. Some projects were found far too expensive for their promised benefits and were canceled. Other goals, particularly on the space station, were scaled back to realistic levels. Where necessary, O'Keefe found more money for projects that promised significant improvements in future capabilities. With these announcements, NASA's most challenging journey — restoring its credibility and regaining the trust of the White House, Congress, and the public — is well underway. — **JAMES OBERG**

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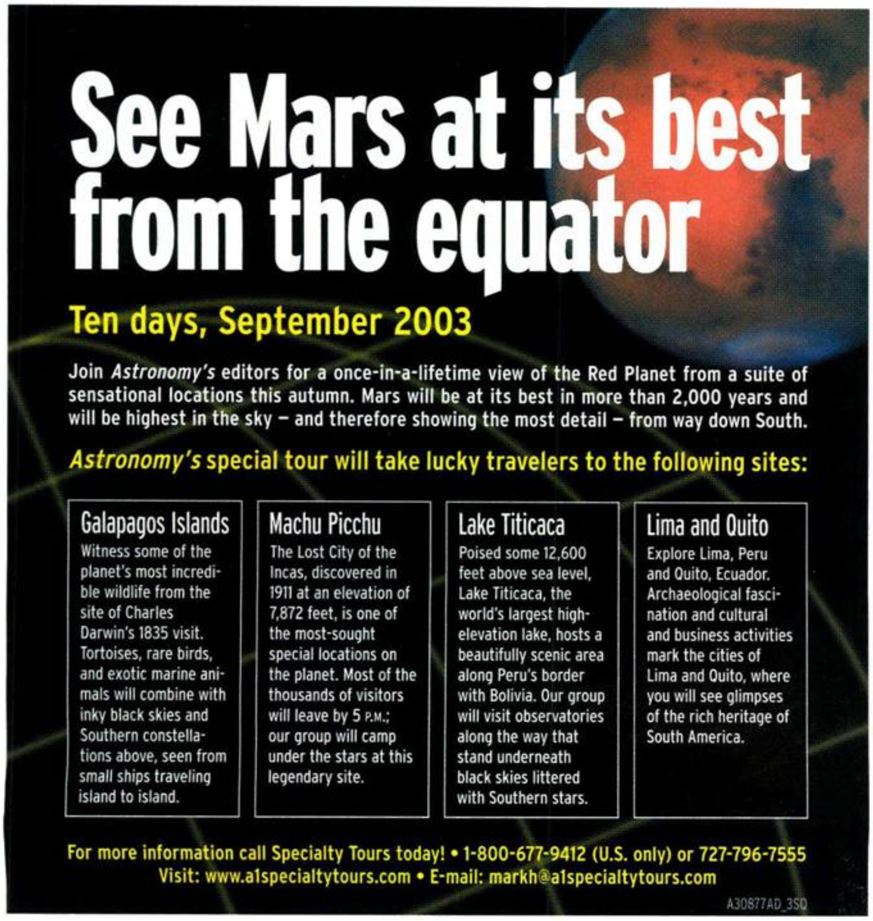

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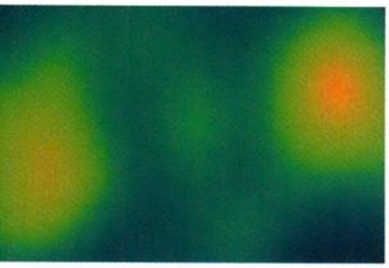
THE AIR FORCE RESEARCH LABORATORY has announced plans to fly a three-satellite "constellation" of microsatellites in 2006 to form a "virtual antenna" which will allow radar imaging of Earth's surface to unprecedented levels of detail.

SPACECRAFT UPDATE

Black Hole Bullets

NASA's Chandra X-ray Observatory monitored the black hole binary SS 433 for 2.7 hours, revealing the presence of never-before-seen hot gas lobes extending away from the system. The lobes are located about 0.25 light-years to either side of the system and have temperatures of 50 million degrees. The lobes are created from gas ejected from the binary system.



LOBES OF HOT GAS extend away from the black hole binary system SS 433. Measurements of the lobe's Doppler shifts show the system is tilted. NASA/JPL

Long-term optical monitoring has shown that bullet-like gaseous blobs are ejected from SS 433 every few minutes, with velocities near a quarter of the speed of light. Not all gas blobs move at the same rate, however, and this causes them to collide. A bullet of gas will move away from the system for several months and then collide with a blob traveling at a different speed. These collisions heat the gas to x-ray emitting temperatures.

"Just like a superhighway, it's a dangerous world out there," adds Simone Migliari, also of the University of Amsterdam. "Blobs of gas are getting rear-ended at speeds in the excess of a hundred million miles per hour!" — P. L. G.

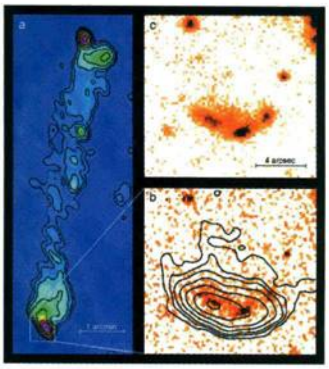
RADIO JETS

Optically visible radio jets

A group of European astronomers recently identified faint optical and infrared emission at the ends of active galaxy 3C 445's radio jets. The separation between the central galaxy and these visible hot spots is 1.5 million light-years, or about 75 percent of the distance between the Milky Way and Andromeda galaxies.

Driven by an active supermassive black hole in the core of the galaxy, 3C 445's jets consist of plasma with strong synchrotron radiation. In the radio image, the jets broaden out and brighten at the ends as they collide with the thin intergalactic medium, creating shocks and hot spots.

M. Almudena Prieto of the European Southern Observatory, along with Gianfranco Brunetti and Karl-Heinz Mack of Italy's Istituto de Radioastronomia del CNR, observed these hot spots in optical and near-infrared light with the Very Large Telescope and found knots of excited gas created by electrons accelerated within the hot spot. The cause of these accelerations is unknown. In addition to a central knot at the tip of the jet, secondary knots are located 10 to 15 thousand light-years to either side.
— P. L. G.



RADIO JETS encase optical hot spots in the active galaxy 3C 445. The radio jets (a) were observed using the Very Large Array in New Mexico. The end points of the jets were observed in optical (b) and infrared (c) light using the ESO Very Large Telescope in Chile. ESO/NRAO

OBSERVATORY NEWS

Lovell gets a face-lift

After 45 years of operation, the Jodrell Bank Observatory's Lovell Telescope has a new look. Technologically advanced, smoother, galvanized steel plates replace archaic, peeling, and rusted surface panels. These new panels not only clean up the telescope's appearance, but also its observational capabilities.

Located at the University of Manchester, the 76-meter Lovell radio telescope has been at the forefront of pulsar research for more than 30 years and is considered the most famous scientific instrument in England.

Updating each of the 340 panels on the giant telescope's surface increases the telescope's already impressive ability to discover new distant pulsars, study the formations of stars in our own galaxy, and help seek out faint radio galaxies in far reaches of the universe. — M. Q.

JODRELL BANK OBSERVATORY'S POWERFUL LOVELL TELESCOPE was resurfaced to improve its imaging efficiency. JODRELL BANK OBSERVATORY

Gemini North named to honor Fred Gillett

In April 2001, infrared astronomy lost a trailblazer. In his memory, family, friends, and colleagues of Frederick Gillett gathered atop Mauna Kea, Hawaii, on November 13 to dedicate the 8-meter Gemini North Telescope as the "Frederick C. Gillett Gemini Telescope." In a career that spanned 40 years, Gillett left an enduring mark on astronomy. "If there is one phrase that describes Fred it would be integrity of purpose," remembers Gemini director Matt Mountain. "This is a key reason why Gemini performs so well today." — JEREMY McGOVERN

SOLAR SYSTEM

Critter search

In November 2002, astrobiologists and robotic engineers at the Canadian Space Exploration Workshop in Ottawa were tasked with proposing research programs for life detection and outlining the technology needed for seeking out life and alien water on Mars. Scooping, drilling, coring, and grinding samples were identified as crucial abilities for future missions.

THE CANADRILL may someday collect samples from below the surface of Mars. CANADIAN SPACE AGENCY

Canadians hope to use their expertise in robotics, geology, and drilling to sniff out the bio-signatures of life in the martian soil and atmosphere. Astrobiologists and engineers devised both lander and rover-based platforms to conduct tests for life at the surface and underground.

In an experiment wish list, workshop participants stressed the need for on-site tests to detect past and present martian life, and pre-cellular chemistry. Remote-robots could test for everything from salt content to pH, including known bio-indicator gases like oxygen and methane. Some scientists even suggested including genetics tests to look for martian DNA. Others envisioned using ground-penetrating radar to look for water and examining potential martian microfossils with scanning electron microscopes.

With NASA considering over a half dozen Canadian proposals for upcoming missions to the Red Planet, a maple leaf-bearing scientific platform on Mars may not be far off. — **ANDREW S. FAZEKAS**

Canada sees Mars in its future

Canada's participation in space exploration may be at a turning point as the nation begins to gear up to take part in the international drive to the Red Planet. According to Marc Garneau, former astronaut and current president of the Canadian Space Agency, Canada is intent on being a leading player in Mars exploration. Laying out a broad roadmap for the nation's push for Mars, Garneau says, "Canada's contribution to any mission to Mars will primarily be science driven, use Canadian technology, and be highly visible to the public," adding, "Canada is all fired up on Mars!"

Garneau was speaking to the country's top space robotic engineers and scientists meeting in Ottawa this past November for a two-day brainstorming workshop on how Canada will partner with NASA on upcoming Mars missions.

Spurring on the Canadian space science community is NASA's invitation to Canada to become a $200-million partner on the 2009 Mars Science Laboratory mission.

Alain Berinstein, CSA Mars team lead, points out that there is a "clear Canadian heritage in space robotics and mining" and says that this may "help define the nation's participation in upcoming missions." With NASA aiming to keep mission costs low and looking for worldwide participation, Canadians hope they can have a chance to be onboard a Mars mission in this decade as an international partner.

With all options on the table, some technology concepts definitely take center stage and appear to be favored by Canada. With safe landing a critical element on any Mars mission, their expertise in the development of laser-based landing systems may help with hazard avoidance and precision touchdowns. As a world leader in robotic technologies, Canada's contributions may take the form of a robotic mining device, already dubbed the "Canadrill," (see story at left) that could extract samples of the planet's subsurface in search of water and evidence of past or present life on Mars. Today Canada has a leading role in terrestrial analog research in the arctic and has a Mars atmosphere analyzer on the Japanese Nozomi spacecraft destined to arrive in 2004.

MARC GARNEAU, president of the Canadian Space Agency. NASA

Canada
MDRobotics

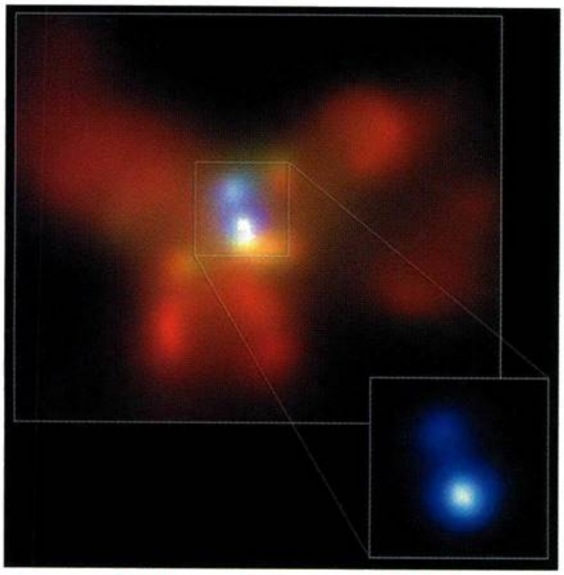
CANADIAN TECHNOLOGY will dig up martian secrets. MDROBOTICS

Garneau says his vision of being a major partner for upcoming Mars missions is built on Canada's talents in robotics, meteorology, and geology. With NASA's upcoming 2007 scout mission and the Mars Scientific Laboratory, the world may see Canadian expertise on Mars soon enough. — **A. S. F.**

TRANSORBITAL, INC. has become the first private company in the history of spaceflight to win approval from the U.S. government to explore, photograph, and land on the Moon. The company hopes to launch its Trailblazer Mission within a year.

BLACK HOLE MERGERS

Collision investigation



BINARY SUPERMASSIVE BLACK HOLES IN NGC 6240 emit x-ray radiation (inset) as they actively consume dust and gas that is visible in the infrared (main image). NASA/CXC/MPE/S. KOMOSSA ET AL.

Astronomers have long known that smaller galaxies merge to form larger ones. With the discovery of supermassive black holes in the centers of many galaxies, the question arises: What happens to the black holes during mergers?

NGC 6240 is an example of an advanced merger, and astronomers have found two supermassive black holes in its core. Roughly 3,000 light-years apart, the two will merge in perhaps a few hundred million years. The major structures of NGC 6240's parent systems have already been destroyed, but the effects of the collision still glow brightly in the form of starbursts and active galactic nuclei.

Prior observations of NGC 6240 revealed central x-ray emission and two nuclei that appeared in radio, infrared, and optical observations. Poor spatial resolution had made it impossible to identify the x-ray source. "The breakthrough came with Chandra's ability to clearly distinguish the two nuclei, and measure the details of the X-ray radiation from each nucleus," says Guenther Hasinger of the Max Planck Institute for Extraterrestrial Physics in Germany.

"With Chandra, we hoped to determine which one, if either, of the nuclei was an active supermassive black hole," says Stefanie Komossa, also of the Max Planck Institute. "Much to our surprise, we found that both were active black holes!" — **P. L. G.**

OBSERVATORY NEWS

ALMA given the Go

A recent agreement between the Chilean government and the European Southern Observatory (ESO) authorizes ESO to construct a new center for astronomical observation in the Andes, on the Plateau of Chajnantor.

64 STATE-OF-THE-ART ANTENNAE will parade across the Atacama Desert as they observe the sub-mm sky. ESO

ESO Director Catherine Cesarsky said the agreement "is an historical step in the astronomical collaboration between Chile and ESO."

The center is for the Atacama Large Millimeter Array (ALMA) and will be comprised of 64 state-of-the-art antennae. These antennae will have an unprecedented sensitivity, exposing astronomers to a fresh perspective on numerous cosmological phenomena. This new center will lead observers into an era of unparalleled discovery. — M. Q.

EXTRASOLAR PLANETS

Big measurement, little planet

The first definitive mass measurement of an extrasolar planet was announced in December 2002. A team of astronomers led by Thierry Forveille used the Hubble Space Telescope to measure small motions in the star Gliese 876. These motions are caused by the gravitational pull of an unseen planet. Prior estimates of the planet's mass gave values between 1.9 and 100 times the mass of Jupiter. The new measurements constrain the exoplanet's mass to between 1.89 and 2.4 Jupiter masses.

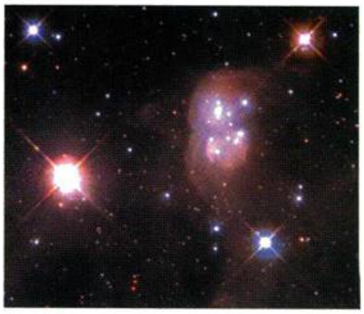
Observations were made by George Benedict and Barbara McArthur of the University of Texas using Hubble's Fine Guidance Sensors. "Making these kinds of measurements of a star's movement on the sky is quite difficult," Benedict emphasizes. "We're measuring angles equivalent to the size of a quarter seen from 3,000 miles away." To measure the planet's mass, Benedict and McArther used data taken over two years during a total of 27 Hubble orbits. — **P. L. G.**

THE VIEW NEAR GLEISE 876'S PLANET may look like this. NASA AND G. BACON/STScI

HUBBLE HERITAGE ARCHIVE

LMC blows bubbles

Nested nebulae hid in the Large Magellanic Cloud. Nebula DEM L 106 fills most of this Hubble Heritage image with wispy gas.



BUBBLES WITHIN BUBBLES grow and merge around a star-forming region. NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

The inner cocoon-shaped nebula, N30B, tightly encloses a star-forming region located just 25 light-years from the star Henize S22 (right side in image). Astronomers M. S. Oey and Y.-H. Chu used N30B as a mirror to look at Henize S22 from a variety of perspectives. They found that the star's spectrum changes with the viewing angle, indicating it is surrounded by a disk.

This is image 58 in the Heritage collection. Qualifying images illuminate the forces shaping the cosmos and expand scientific understanding of the universe. — **KELLEY KNIGHT**

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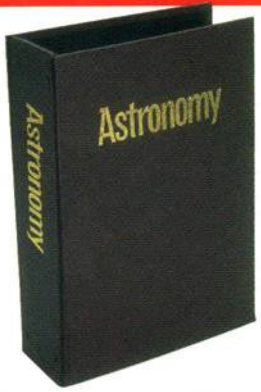

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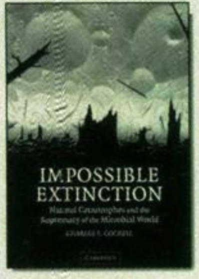

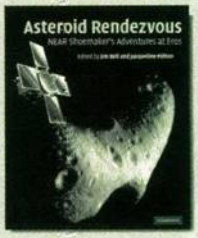

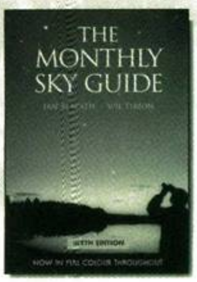

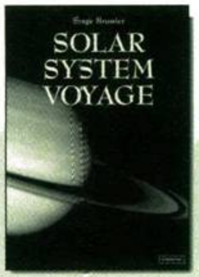

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There's Only One Direction To Look To See The Brightest New GPS Stars.

Introducing the NEW Celestron NexStar® 5i and NexStar® 8i. Now You Can Expand Your System As You Expand Your Horizons.

Celestron's affordable NexStar 5i and NexStar 8i are exciting new additions to our renowned NexStar family of computerized GoTo GPS telescopes that includes the NexStar 8GPS and 11GPS. NexStar 5i and NexStar 8i take the best of our coveted NexStar 5 and 8 to the next level of performance and operating features. These new GoTo's include ***all*** of Celestron's newest hardware and software enhancements in an affordable and expandable system. Most important, these two new NexStar GoTo's will fully align when used with the **optional CN16 GPS accessory**, and you can put the power of our newest software features and expanded object database to work with the ***optional upgraded hand control***.

New Hardware Features:

Two Ports Conveniently Located On The Drive Base:

- **AutoGuide Port** — Easy connection of AutoGuider for astrophotography.
- **Auxiliary Port** — Use for smart accessories like our **optional CN16GPS accessory**.

Upgraded Optional Hand Control With New Software Features.

When you upgrade from the standard directional hand control to Celestron's optional upgraded hand control, you get a myriad of important new functions. The upgraded hand control is the next evolution of the most user-friendly, intuitive hand control in the industry.

Upgraded Hand Control Features:

- **GPS Align Compatible (with optional CN16 GPS accessory)** — Plug the optional CN16 GPS accessory into the auxiliary port and the telescope automatically aligns with no data input necessary.
- **Auto North and Level Compatible (with optional CN16 GPS accessory)** — Automatically finds north and level with more precision than can be done by hand, getting you closer to your alignment stars.
- **Hibernate** — This power saving feature lets you power down the telescope without losing your alignment (input time if CN16 GPS accessory is not attached). Great for finding planets in the daytime after aligning at night or observing day after day without having to re-align.
- **Database Filter Limits** — User-defined so that only objects visible above the horizon are displayed on the hand control.
- **Wedge Align Algorithm** — Automatically aligns the telescope to the celestial pole. Essential when you are performing polar alignment on an Equatorial wedge.
- **Quick Align** — An easy way to get an Alt/Az telescope tracking without actually aligning on two stars.
- **40,000 Object Database** — A newly enlarged and expanded programmable user database.
- **User-Defined Slew Limits** — Prevents the telescope from slewing beyond the user-defined horizon.

NEW NexStar Software. Now Our Beauties Come With More Brains.

The beauty of Celestron's NexStar GPS telescopes has always been their unique appearance characterized by their **patented** design, engineering innovations like **patented** AutoAlign, user-friendly intuitive software, and solid aluminum construction. We've made them even more attractive by upgrading the software with additional new features that are ***included with all Celestron NexStar GPS telescopes including our new 5i and 8i.***

New Software Features:

- **Compass Calibration** — Allows you to point to true north more accurately, by compensating for magnetic north offset and local anomalies.
- **Polar Alignment Routine** — Facilitates polar alignment for CCD imaging or conventional 35mm astrophotography.
- **EQ AutoAlign** — Now the patented AutoAlign is available even when the telescope is mounted on a wedge.
- **Database Filter Limits** — Now available in Equatorial mode as well as Alt/Az.

NexStar 5i shown with optional Computerized Hand Control, optional Tripod, and accessories for astrophotography.

NexStar® 5i
$899*
+ $50 Shipping & Handling
Optional Computerized Hand Control: **$149**
Optional Tripod: **$149**

NEW!
GPS Accessory Plugs Into Auxiliary Port
CN16 GPS accessory:
$199

NexStar 8i shown with optional Computerized Hand Control, optional Tripod, 1.25" Ultima Ocular, and optional CN16 GPS accessory.

NexStar® 8i
$1199*
+ $75 Shipping & Handling
Optional Computerized Hand Control: **$149**
Optional Tripod: **$149**

*Suggested Mail Order Retail Price

NexStar™ 5i and 8i Optional Accessories:

CN16PS Accessory — #93963 Mounts to both the NexStar 5i and 8i. Converts the telescope to GPS align for automatic alignment without manually entering any data. — **$199**

Computerized Hand Control — #93962 Full-featured hand control has all of the newest hardware and software enhancements as the NexStar 8GPS and 11GPS hand control. — **$149**

Heavy Duty Tripod — #93501 Heavy Duty Tripod with adjustable legs. — **$299**

CELESTRON®

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www.celestron.com

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Smaller Cost. Bigger Value!

Now the NexStar® 4GT is an even better value. New lower price, improved features, and portability make this high performance GoTo telescope a must-have!

Featuring high-quality Maksutov-Cassegrain optics, the NexStar 4GT is an ideal telescope for observing and photographing the wonders of space. Incredible light-gathering and a wide field of view gives you views 189% brighter than a 60mm refractor. Sturdy metal construction provides an extremely stable observation platform making observing at higher magnification much easier.

Computerized capabilities like Auto Align, automatic Tour Function, easy-to-use hand control and 4,000+ object database all help make the NexStar 4GT a superstar telescope at a super affordable cost. The NexStar 4GT's deluxe features combine with Celestron's uncompromising optical standards to give amateur astronomers one of the most sophisticated and easy to use telescopes available on the market today.

NexStar® 4GT

$499*

+ $40 Shipping & Handling

NexStar 4GT shown on optional tripod (Tripod #93497- $149)

Improved Features Include:

- **Two-star alignment** — Allows you to do a two-star alignment just like other NexStar GoTo telescopes.
- **Quick-Align** — Allows the telescope to align itself without being aimed at two alignment stars.Works the same as the NX 8GPS and 11 GPS.
- **Filter Limits** — Displays only those objects within the set altitude filter limits. Works the same as NX 8GPS and 11GPS except the hand control displays a warning if there are no objects within the set filter limits.
- **Slew Limits** — Sets the limit that the telescope can slew in altitude. Will display a warning if you try to slew outside of your slew limits. Works the same as the NX 8GPS and 11GPS.
- **RS-232 Compatible** — Allows the telescope to communicate with a computer. Works with popular astronomy software such as "The Sky" or "Starry Night".

For additional information about the Celestron NexStar 4GT or other Celestron products, as well as the location of your nearest Authorized Celestron Dealer, please visit us at:

www.celestron.com.

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IMPROVED FEATURES!

*Suggested mail order retail price.

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Anyone can sell you a telescope.

Authorized Meade Dealer

Meade ETX-90EC
$495 ($545 w/UHTC)
Meade ETX-105EC
$695 ($770 w/UHTC)
Meade ETX-125EC
$895 ($990 w/UHTC)
#497 Autostar **$149**

ETX-125EC

Hardly a day goes by that we don't get a note or e-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. Dealer so and so advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!"

If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who can help you get the most telescope for your dollar. That's exactly who you'll find at ***astronomics*** – people with a combined total of 160 years of experience using and selling telescopes!

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the hundreds of Celestron, Discovery, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, and Vixen scopes we stock. And with our large inventory, we can usually ship you the right scope right away.

astronomics. No hard sell. No guesswork. Just honest advice, the *right* scope, and a good price. Call us at (405) 364-0858 and find out for yourself.

Our free catalog helps you pick the right Celestron, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, or Vixen scope.

For the most detailed and fully illustrated information on individual products, visit our web site at **www.astronomics.com**. If you'd prefer, call us at (405) 364-0858, or e-mail us, for your *free* copy of our catalog AST. It includes our 8-page guide on how to pick the right scope, plus your discount prices on the 1500+ products we carry – from Antares, Astrozap, Bausch & Lomb, Bushnell, Canon, Celestron, Coronado, Discovery Telescopes, Fujinon, JMI, Kahles, Leica, Losmandy, Meade, Minox, Miyauchi, Nikon, Parallax Instruments, Pentax, Questar, Rigel Systems, SBIG, Sirius Optics, Sky Publishing, Software Bisque, Starbound, Starlight Instruments, Stellarvue, Swarovski, Swift, Takahashi, TeleVue, Thousand Oaks, TMB, Vernonscope, Vixen, Zeiss, and more. (Sorry, U. S. sales only.) The catalog is yours for only the cost of a one minute phone call. The information and pricing we send will make it the most useful minute you'll ever invest in astronomy. Prices in this ad as of 12/5/02 and subject to change.

"Optics as good as I have seen . . . in any telescope . . . at any price."

TMB 100

A review in June's *Sky & Telescope* said the **TMB 100** 4" f/8 ED triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price." It just confirms what dozens of our very satisfied customers have been saying about their TMB apo refractors for months.

Not only do the TMB ED apo refractors have optically unsurpassed triplet optics and precision mechanics (such as a 3" focuser), but many of the sizes listed below are available from stock. Even those that may be temporarily out of stock are usually available again in few short months, not a few years, as is the case with another well-known brand.

Why wait years for another triplet apo when you can be observing with the best right now? For more details and pictures, visit our website to see the apo refractors that are the talk of experienced astronomers everywhere.

TMB 80/6 80mm (3.1") f/6	$\$1690^{00}$
TMB 80/7 80mm (3.1") f/7	1690^{00}
TMB 100 100mm (4") f/8	3290^{00}
TMB 105 105mm (4.1") f/6.2	3290^{00}
TMB 152 152mm (6") f/7.9	6990^{00}
TMB 175 175mm (7") f/8	$11,990^{00}$
TMB 203 203mm (8") f/9	$19,990^{00}$
TMB 254 254mm (10") f/9	$39,995^{00}$

The new Meade LXD55 EC scopes . . . *add go-to when you need to.*

Meade 5" AR-5EC refractor
$579

Some observers enjoy hunting for celestial objects the way the pioneering astronomers did – by eye, star hopping from object to object. Others want a go-to scope to do the hunting for them, but have a budget that says, "Can't afford a go-to yet." For both groups, the Meade LXD55 EC scopes are the answer!

The 5" EC multicoated achromatic refractor and fast focal ratio Schmidt-Newtonian 6" and 8" reflectors (with either standard or optional UHTC optics) are complete working scopes, with standard dual-axis DC drives and a four-speed/four direction EC hand control (which are costly options with competitive scopes). You can star hop or use setting circles to find objects. Once found, the scopes track those objects automatically while you observe.

For the purist or the observer on a budget, they're all the scope you need. *But* . . . if you add an optional Autostar computer later, you'll have a fully computerized go-to telescope with 30,000 stars and objects in its memory. You can have as much or as little automation as you want, at a price you can afford *now!*

$729
Meade 8" SN-8EC f/4 reflector
($854 w/UHTC)

Want the latest TeleVue telescope or eyepiece? We have it in stock.

Whether it's the newest telescope or the newest eyepiece (like the 3mm to 6mm Nagler zoom at $380), if it's from TeleVue, chances are good we have it in stock. Gibraltar, Panoramic, and TelePod mounts; Nagler, Radian, Panoptic, and Plössl eyepieces; Powermates and Barlows; Everbrite diagonals; and more – we have it all. Others say they carry TeleVue, *but we actually keep it stock.* Call us and see.

All packages come without a mount, but with an eyepiece, star diagonal, tube ring for mounting, and case. Basic optical tubes, without accessories, are also available.

NP-101 **$3595**
TV-85 **$2080**

NP-101, package, without mount	$\$3595^{00}$
TV-102, package, without mount	2635^{00}
TV-102, optical tube only	2200^{00}
TV-85, package, without mount	2080^{00}
TV-85, optical tube only	1680^{00}
TV-76, package, without mount	1675^{00}
TV-76, optical tube only	1275^{00}
Pronto, package, without mount	1120^{00}
Pronto, optical tube only	775^{00}

Vixen. European best-sellers. Now in the U. S.

For many years, the high quality of Vixen telescopes and optical accessories from Japan has made them best-sellers in Europe. Now, that same high Vixen mechanical and optical quality is also available in the U. S. – imported by TeleVue, a company with a sterling reputation for quality of its own.

Whether it's a telescope, a German equatorial mount, or a visual or photographic accessory, if it's from Vixen, the chances are good it's in our inventory. We have all the Vixen Lanthanum long eye relief and wide angle long eye relief eyepieces ready to ship. Also in stock are the well-known and standard-setting Great Polaris and Great Polaris DX mounts to use with your own optics. If you want optics that are out of the ordinary, we have Vixen's ED glass, fluorite, and dual ED doublet apochromatic refractor optical tubes and complete telescopes. If it's a Vixen, it's probably in our stock right now. Check our website for a complete listing of available items or call us and see for yourself.

$2200
Vixen GP ED102S
4" f/9 ED apochromatic refractor
(shown with optional motor drive)

The best CCD book. Period.

Before you spend $3000 on a CCD camera, spend $49.95 on this book. It will be $49.95 well spent.

Ron Wodaski's book **The New CCD Astronomy** is simply the best and most complete reference available about CCD imaging for the beginning to advanced CCD astrophotographer. It includes everything you need to become proficient at CCD imaging, including a free subscription to on-line updates and reference materials. This is the only CCD reference book you'll ever need to buy. *Period.*

Over 1,000,000 people a year visit our website for reliable info, helpful features, and secure on-line shopping.

www.astronomics.com

Our four brands of light pollution filters bring dark skies to your light-polluted world.

If city lights are blocking your view of the heavens, you can get rid of that light pollution with one of the many light pollution filters we stock. They often make the difference between seeing nebulas and galaxies from cities and suburbs and missing them completely.

We carry **Celestron** broadband light pollution filters in both 1.25" eyepiece and Schmidt-Cassegrain rear cell versions.

We carry **Meade** broadband, narrowband, and Oxygen III filters in both 1.25" eyepiece versions and rear cell versions for Schmidt-Cassegrain use.

We carry **Sirius** 1.25" and 2" broadband light pollution filters – nebula, Oxygen III, H-Beta, planetary contrast enhancement filters, and Neodymium planetary contrast filters for eyepiece use; their variable filter system; and their IR and UV photo filters.

We carry the **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" versions for eyepiece use.

We stock Pentax XL eyepieces from $\$227^{\underline{50}}$.

From 5.2mm to 40mm, we stock all of the Pentax wide field (55° to 65°) XL eyepieces. Each has a rotate-to-adjust-the-eye-relief eyecup, ED glass for exceptional edge to edge sharpness, and a long 20mm eye relief that's perfect for those who wear eyeglasses.

5mm 1.25"	$\$244^{50}$
7mm 1.25"	237^{50}
10.5, 14, 21, or 28mm 1.25"	227^{50}
40mm 2"	244^{50}
8-24mm zoom 1.25"	379^{00}

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We'll sell you the *right* telescope.

Why wait? We'll ship your Meade LX90 from stock.

Meade 8" LX90

Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade scope you want from stock . . . right now . . . at the right price . . . right here at ***astronomics.***

The **Meade LX90** will let you enjoy 8" go-to astronomy for not a lot of money. An LX90 with standard optical coatings is only $1695. UHTC (Ultra High Transmission Coatings) optics that have up to 20% brighter images are only $1870. Both versions come with a heavy-duty adjustable height tripod, an Autostar go-to computer with a built-in 30,223 star and object data base, a big and bright 8 x 50mm finder, and a 26mm Super Plössl eyepiece.

We usually have the LX90 in inventory at all times (both the standard and UHTC optics versions), so the chances are good you can get *your* LX90 with little or no delay. If Meade is shipping the LX90 *(or any Meade telescope)* for a dealer to keep in stock, the chances are very good that we *have* it in stock.

7" to 10" Meade GPS UHTC scopes ship from stock. They do all the work so you can see 20% more.

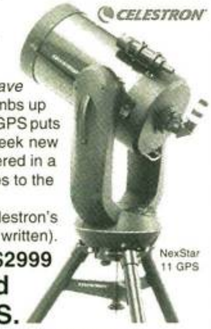
Meade 8" LX200 GPS with UHTC

$2670

Meade LX200GPS telescopes have all the features you've dreamed about since you started astronomy – plus optional UHTC (Ultra High Transmission Coatings) optics that give you up to 20% higher light transmission so you can see 20% more of the Universe. Meade's *fully automatic* GPS (Global Positioning Satellite) alignment system, with its true north and true level sensors and automatic magnetic declination correction, takes the time and guesswork out of setting up your scope. You'll be observing in mere minutes. The built-in computer, with a database of over 145,000 stars and objects, will find objects for you *automatically.* You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them.

We keep the 7", 8" and 10" Meade LX200GPS scopes in stock. Chances are good we have one in stock for you.

A Celestron NexStar 11 rave review. You can have a NexStar next week!


CELESTRON

$2999

NexStar 11 GPS

Celestron's 11" go-to GPS scope – the **NexStar 11 GPS** – got a *rave* review in *Sky & Telescope.* The review gave it "an enthusiastic two thumbs up and a gold star." They said it has "brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

Starbright multicoated Fastar-compatible optics are *standard* with Celestron's NexStar 11 GPS. We have the NexStar 11 GPS in stock (23 as this was written). Call us and you can be observing with yours in about a week.

Multicoated optics? Standard on Celestron's NexStar 8 GPS.

NexStar 8 GPS

$2499

The 8" Celestron **NexStar 8 GPS** (22 on hand as this was written) has all the bells and whistles you expect from a GPS scope, including *standard equipment* Starbright high transmission multicoated optics for brighter images. And you can easily convert its unique Fastar optics to a blazingly fast f/1.9 focal ratio for wide field CCD imaging.

With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the NexStar 8 GPS will record a huge 32 x 42 arc minute field. That's larger than the full Moon and more than three times the sky area imaged by a $7695 camera on other 8" telescopes without Fastar optics!

Of all the computerized GPS scopes, *only the Celestron NexStars have multicoated Fastar optics!*

The *new* Celestron CGE series scopes. Designed to meet a mounting demand.

$4149

Celestron CGE1100

Astrophotography with a fork-mounted go-to Schmidt-Cassegrain does have its drawbacks. You can't take long exposure photos with an altazimuth mount scope without adding a costly equatorial wedge or field derotator. If you use a wedge, you can't image near the celestial pole or the southern horizon, and tube vibrations become a problem. Use a field derotator and you both lose periodic error correction and can't image at the zenith. In larger apertures, fork-mounted scopes require two people to transport and set up.

Celestron's CGE go-to computerized German equatorial mount scopes solve all these problems. Even the largest 14" CGE1400 can be set up by one person. A German mount can access all parts of the sky, without adding a wedge or field derotator. And a German equatorial mount is noted for its lack of vibrations.

Multicoated optics, available as complete go-to systems in apertures from 8" to 14" and as a go-to mount only, optional GPS available for only $199. See our website for full details.

A 5" GPS-ready scope for only $899!

NexStar 5i

$899

shown with optional photography accessories, tripod, and computer

The **Celestron NexStar 5i** is the first 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" telescope has a GPS system! Even better, the modular nature of the NexStar 5i means that you can build up to a fully automatic GPS system gradually, starting at only $899 for a complete working tabletop scope and adding computer, GPS, etc., as wanted. And multicoated optics are *standard equipment* with the NexStar 5i, not an extra-cost option. NASA uses 5" Celestron multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium images?

Eyepiece storage cases from $2.49.

Bolt-type containers protect eyepieces dew and dust. Foam inserts cradle eyepieces to protect them from accidents. Our website at **www.astronomics.com** lists which eyepieces fit into which containers (including other containers not listed below).

42mm x 60mm holds most Celestron NexStar, Meade Series 3000, and TeleVue Plössls.	**$2.49**
52mm x 80mm Holds TeleVue Radians, Nagler 6, most Barlows, large Celestron Ultimas, etc.	**$3.49**
65mm x 80mm Holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	**$3.99**

> I am very happy with my telescope I ordered from yall . . . you are my number 1 telescope supplier.
>
> **Customer Quote of the Month #132**

The new Celestron Modular i Series 8" GPS SCT starts at only $1199!

NexStar 8i

$1199

shown with optional tripod and computer

If you compare prices and specs, you'll see that the **Celestron NexStar 8i** go-to costs less than other comparably-equipped 8" scopes. Starting at only $1199 for a complete working dual-axis drive scope, you can add the options that you, and your budget, feel comfortable with. An *iCOMP* computer hand control with 40,000 deep space objects in memory is $149. A lightweight travel tripod is $149. A heavy duty tripod (same as the NexStar 11 GPS) is $299. If you want the convenience of GPS auto-alignment, add it for only $199. No matter how you outfit your NexStar 8i, it's enough scope to keep you observing for the rest of your life, at a price that leaves other scopes behind.

A whole lot less shaking going on!

Canon

Sky & Telescope said that hand-holding Canon image-stabilized binoculars was "truly a quantum leap in binocular observing," Canon images are rock-solid, not jittery, no matter how unsteady your hands. You'll see more detail than with conventional binos. There are big 15 x 50mm and 18 x 50mm models excellent for astronomy. Full details are on our website.

Sell your used telescopes and accessories quickly by using the classified ads you can run *for free* at

www.astrofieds.com

Discovery Dobs are not cheap . . . just inexpensive.

8" f/6 DHQ

$449

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use inexpensive, imported, mass-produced optics that are only spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. For only $49 more, you can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter!

Premium Dobs are also available in 10" to 17.5" apertures. And for those who need portability, easy set-up and take-down truss-tube Dobs are available in apertures of 12" to 24". Here are the 6" to 10" Discovery DHQ Dob prices:

6" f/5 Discovery DHQ	**$339.00**, plus $49 freight
6" f/8 Discovery DHQ	**$339.00**, plus $49 freight
8" f/6 Discovery DHQ	**$449.00**, plus $49 freight
8" f/7 Discovery DHQ	**$449.00**, plus $49 freight
10" f/4.5 Discovery DHQ	**$649.00**, plus $69 freight
10" f/5.6 Discovery DHQ	**$649.00**, plus $69 freight

The Stellarvue refractor is a "hot new product."

AT1010A **$499.95** shown w/optional diagonal and eyepiece

The 80mm f/6 **Stellarvue AT1010** achromatic refractor was named a "Hot New Product" in the December 2001 issue of *Sky & Telescope.* Even better, independent reviews say it competes favorably with ED semi-apochromatic scopes that cost twice its modest price, and that it easily outperforms imported achromatic scopes in color correction and resolution. The AT1010CN has triple tested hand-assembled optics, tube rings, a tripod adapter, a 2" focuser with 1.25" adapter and T-threads, red dot finder, oversize rubberized focus knobs for easier use in cold weather, and a soft padded carry case. It's a super deal and it's in stock to ship now. It's one of several Stellarvue refractors we keep in stock, in apertures from 78mm to 102mm, *including APOs.*

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Our multiple award-winning Internet address: www.astronomics.com

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No credit card surcharge. $6.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged.

{ COSMOLOGY }

Will dark energy steal all the stars?

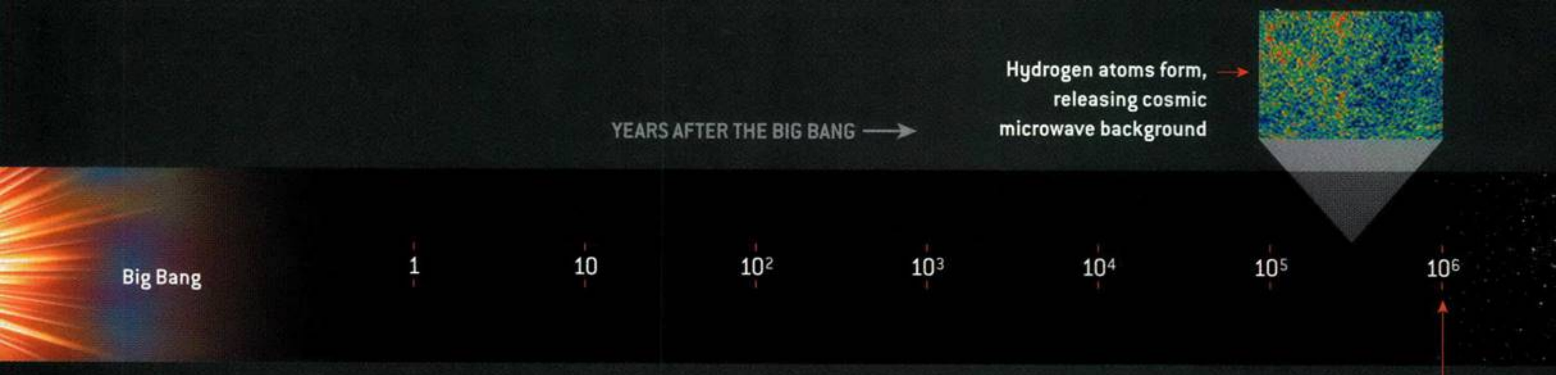
Armed with new supercomputer calculations, astronomers probe where cosmic acceleration is taking us. /// BY STEVE NADIS

NASA, HOLLAND FORD (JHU), GARTH ILLINGWORTH (UCO/LICK OBSERVATORY), NARCISO BENITEZ (JHU), MARK CLAMPIN (STSCI), GEORGE HARTIG (STSCI), THE ACS SCIENCE TEAM, AND ESA

Ever since 1998, when astronomers found evidence that the expansion of the universe is speeding up rather than slowing down, a few practitioners have been trying to determine exactly what this means for both the cosmos and their beloved field. Will astronomy have a future in a universe dominated by dark energy — a mysterious, repulsive form of energy that fills the vacuum of space, counteracting gravity at every turn?

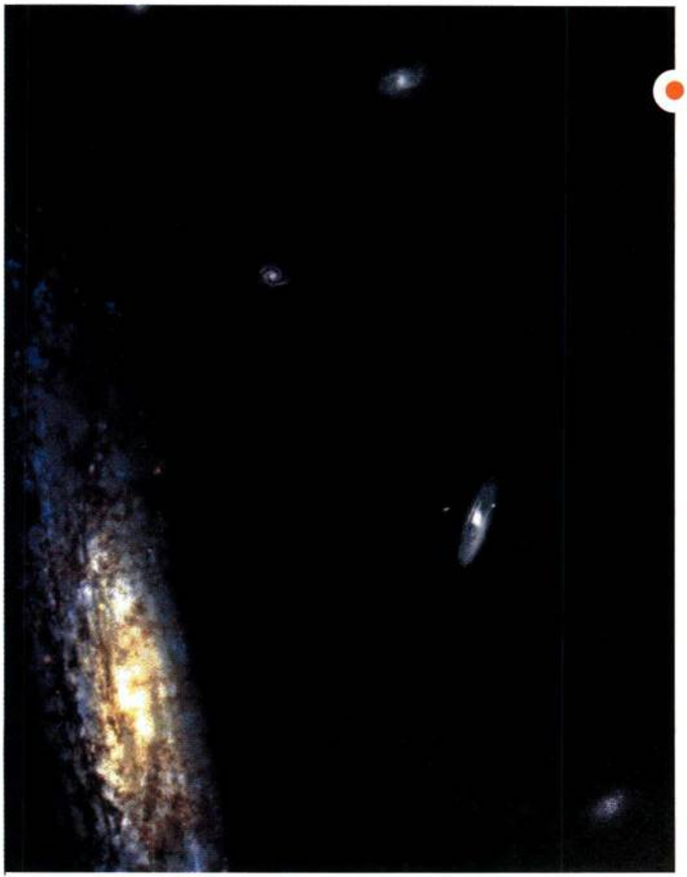
If the prospect sounds ominous, consider this: Dark energy is thought to constitute about 70 percent of the energy in the universe today. But because it seems to be a property of space itself, dark energy will grow along with space. When the universe is twice its present age, according to some theorists, dark energy will comprise 97 percent of the total, rendering matter insignificant. It's as if we've just caught a glimpse of a giant monster that will gradually take over our world. So, assuming anyone is around tens of billions of years from now to make observations, what will they look at? And, more to the point, will there be anything left to see?

Some clues are emerging from computer simulations by astrophysicists Kentaro Nagamine and Abraham Loeb at the Harvard-Smithsonian Center for Astrophysics. When the universe is approximately twice its present age, the Milky Way will merge with the Andromeda Galaxy and other star systems in the Local Group, although gravity will not be strong enough to keep the Virgo Cluster in tow. One by one, distant galaxies will recede, becoming dimmer until they totally fade away.


Hydrogen atoms form, releasing cosmic microwave background
YEARS AFTER THE BIG BANG →
Big Bang
1
10
10^2
10^3
10^4
10^5
10^6
First stars

BOOKENDED BY THE DARK AGES of the early universe, before stars formed, and the darkness to come, when space will expand so much that light traveling from distant galaxies will never reach us, we are witness to what has been called the Golden Age of astronomy. TIMELINE BY ROEN KELLY, *ASTRONOMY*; IMAGES FROM LEFT TO RIGHT: CMB SIMULATION BY NASA; STARBURST PAINTING BY ADOLF SCHALLER FOR STScI; STScI; B. KEEL; ROE/AAO.

To the untrained eye, the night sky then would look similar to what we see today. Sure, there'd be about twice as many stars as a result of the Milky Way-Andromeda merger, and the stars would be spread more evenly as the galaxy becomes more elliptical. The casual observer might not notice these changes. But in a few more billion years, "the rest of the universe would literally disappear," says Lawrence Krauss, a physicist at Case Western Reserve University who has done calculations with colleague Glenn Starkman on the fate of a universe governed by dark energy.



WHILE DARK ENERGY PUSHES space apart, gravity will still win out locally. This artist's rendering shows a possible view from outside the Milky Way (left) 7 billion years from now. Seven billion years after that, the Milky Way will merge with neighboring galaxies. In 100 billion years, space will expand so much that nothing beyond this mega-galaxy will be visible to those living inside it. DAVID AGUILAR

Other computations that look ahead 100 billion years reveal that the web and filamentary structures upon which galaxies cluster eventually get stretched to the breaking point. In place of the familiar cosmic web, we're left with isolated clumps of galaxies separated by unimaginably huge voids.

One might wonder, what's the point of such exercises? The Sun will get so hot in another billion years that life on Earth will no longer be an option. Assuming we can somehow escape to a hospitable planet or spaceship, why should we concern ourselves with what might happen 100 billion years from now? The answer, in part, is because we can. The laws of physics work in both directions, says Loeb, so "trying to imagine the future is a legitimate and worthwhile endeavor, especially now that we have some robust data about cosmic acceleration."

"Most of our colleagues are focused on the past because that's what the sky gives you," adds Gus Evrard, a cosmologist at the University of Michigan. He and fellow researchers Fred Adams, Michael Busha, and Risa Wechsler run these long-term cosmic forecasts. "One hundred billion years is a ridiculous timescale compared to human lifetimes, which makes the whole project seem fanciful. Yet we think nothing of looking backward 14 billion years and do it all the time. So why not look forward and see what we find out?"

Blinded by the night

What has been learned so far? Calculations by Loeb, as well as by Krauss and Starkman, impose limits on the amount of information we can collect. Until evidence of dark energy became manifest, astronomers assumed the amount of new information available to us was practically boundless. Our horizons were nearly infinite — if we were patient and waited long enough, we could learn more and more about the far reaches of the universe. Now it appears we have to resign ourselves to a future of narrowing possibilities.

That's because in an accelerating universe, the speed of galaxies flying away from each other will one day overtake the speed of light — photons won't be able to catch up with the rapidly expanding space through which they travel, explains Loeb. Think of an ant walking on top of an expanding balloon. "If the balloon expands forever at a rate faster than the ant is propagat-

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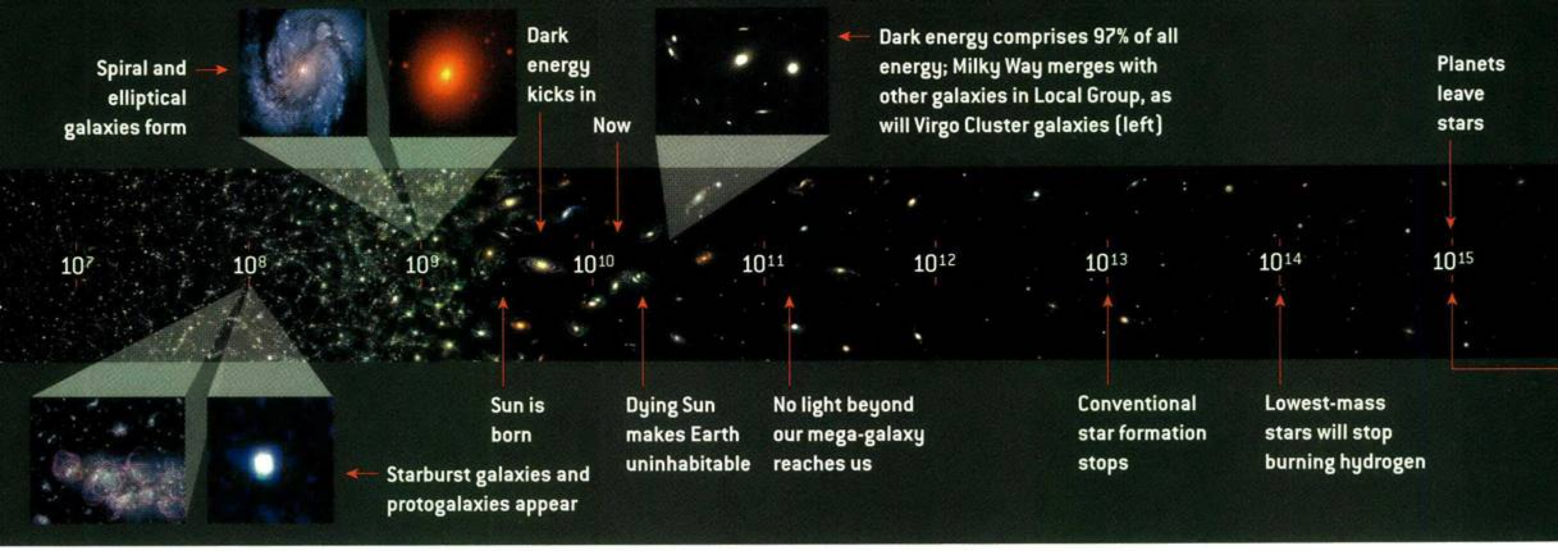

Spiral and elliptical galaxies form
Dark energy kicks in
Now
Dark energy comprises 97% of all energy; Milky Way merges with other galaxies in Local Group, as will Virgo Cluster galaxies (left)
Planets leave stars
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}
Sun is born
Dying Sun makes Earth uninhabitable
No light beyond our mega-galaxy reaches us
Conventional star formation stops
Lowest-mass stars will stop burning hydrogen
Starburst galaxies and protogalaxies appear

ing on its surface," he says, "then the ant will visit only a very small section of the balloon."

In an accelerating universe, there is a horizon surrounding a galaxy like ours — a distance beyond which light cannot reach us — just as there is an event horizon surrounding a black hole. It is impossible to look beyond our galactic horizon, in the same way it is impossible to peer inside a black hole.

The bottom line, says Tom Banks, a physicist at the University of California, Santa Cruz, is that if the cosmological constant has a positive value, our horizon is finite and, in time, there'll be fewer and fewer interesting things to measure. "We can't say what happens to my friend living on another galaxy once it disappears beyond our horizon, nor can we say what happens to an object once it crosses an event horizon and falls into a black hole." The same, of course, would be true for observers confined to different galaxies. As a consequence, knowledge of the universe will be fragmented, with observers studying their own small pieces of the puzzle but forever denied the whole.

We think nothing of looking backward 14 billion years and do it all the time. So why not look forward and see what we find out?

Marooned in the Milky Way

Galaxy clusters like the Local Group, Virgo, and Coma will become entities unto themselves, "island universes" cut off from the rest of the cosmos by the vastness of space. Observers within our new galaxy complex will be limited by the "horizon scale" — a sphere of radius 12,600 megaparsecs or about 40 billion light-years, according to Adams, that is like an impenetrable wall. In 100 billion years, Loeb says, "We'll be the only galaxy we see in the darkness that surrounds us."

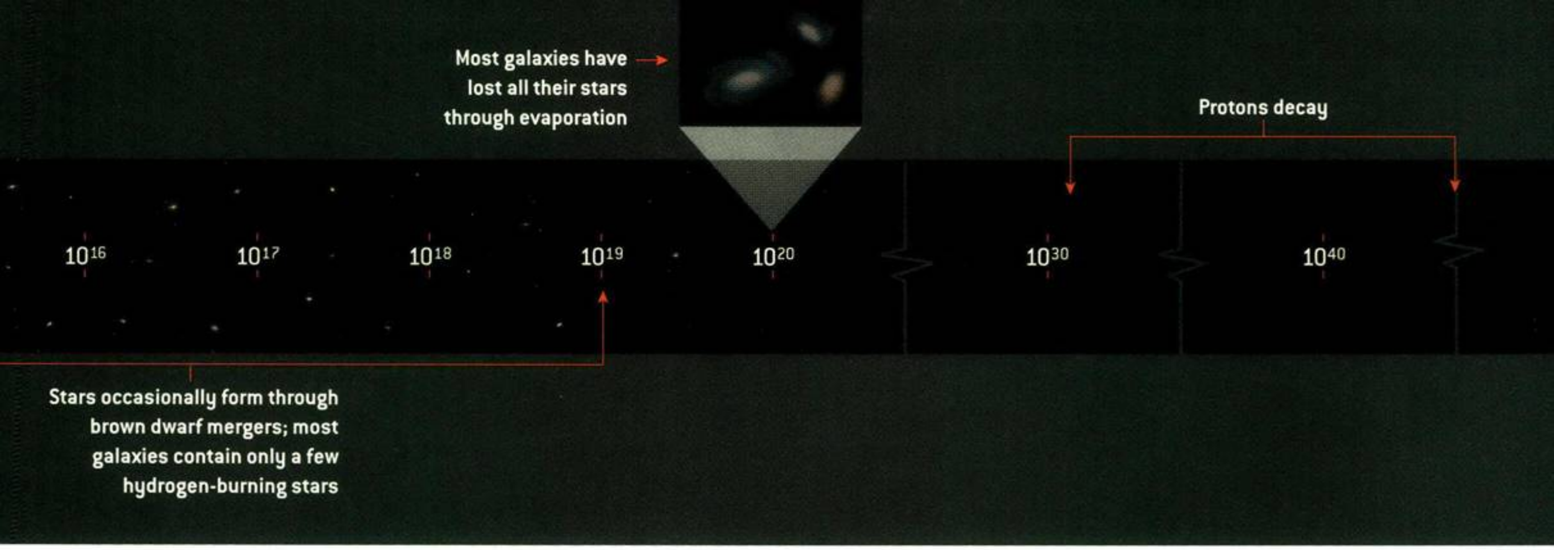
Dark energy also will inhibit the formation of galaxies, clusters, and superclusters, as the gravitational instabilities that made these structures cohere is overcome by an even more powerful anti-gravity force. In addition, Loeb says, we'll never get the chance to watch galaxies evolve beyond a certain stage because the objects will disappear from view. Cosmic acceleration will also limit opportunities for extragalactic communications, with some distant galaxies already out of range. "That's a blow to the SETI community, but maybe there's nothing out there," he says.

When the universe is 10 times older, we won't be able to see anything beyond our own mega-galaxy, and extragalactic astronomy will cease to exist. When we can no longer peer into the distant past, observational cosmology will also come to an end. Light that has been traveling since shortly after the Big Bang, called the cosmic microwave background radiation, won't completely disappear, but it will become so distended by cosmic expansion that the wavelength of these photons will exceed the length of the observable universe, making them undetectable. "If any astronomers are living 100 billion years from now, they could have a pretty boring life," Evrard says.

Adams wastes little thought about what astronomers might or might not be doing at that time. "I don't have anything to say about what humans might be up to in a billion years," he notes. "But if you ask me what a star will be doing in a billion years, I have plenty to say." A more sensible focus, for him, is to look at what will happen to the astrophysical objects that populate our universe as it is ripped apart by cosmic acceleration.

Once other galaxies recede from view, astronomers will be limited to studying objects within our own little piece of heaven. Galactic astronomy, in other words, will be the only game in town. Although our Sun will be around for just another 5 billion or so years, the lowest mass stars are expected to burn hydrogen for 10 to 20 trillion years, according to Adams. New stars will continue to form, but with less material available, most of these stars will burn out within 100 trillion years. At that point, the only way to make new stars will be through collisions between brown dwarfs. Since these crashes occur infrequently, one might expect only a few stars to shine in each galaxy.

Stars are occasionally hurled from galaxies, so statistically, if we wait long enough (Adams predicts 10^{20} years), galaxies themselves will cease to exist. No longer bound to galaxies, dead stars will be scattered far and wide. These objects will lead a lonely existence until they eventually disintegrate due to proton


Most galaxies have lost all their stars through evaporation
Protons decay
10^{16}
10^{17}
10^{18}
10^{19}
10^{20}
10^{30}
10^{40}
Stars occasionally form through brown dwarf mergers; most galaxies contain only a few hydrogen-burning stars

decay, although the lifetime of protons is so long it has yet to be experimentally determined.

The last remaining astronomical objects, black holes, will eventually "evaporate" due to Hawking radiation. For the biggest black holes, this process is expected to take 10^{100} years. Apart from photons stretched to ungodly dimensions and some stray particles — electrons, protons, and neutrinos — everything else will be gone. "There'll be nothing left to measure and no one left to measure it," says Banks.

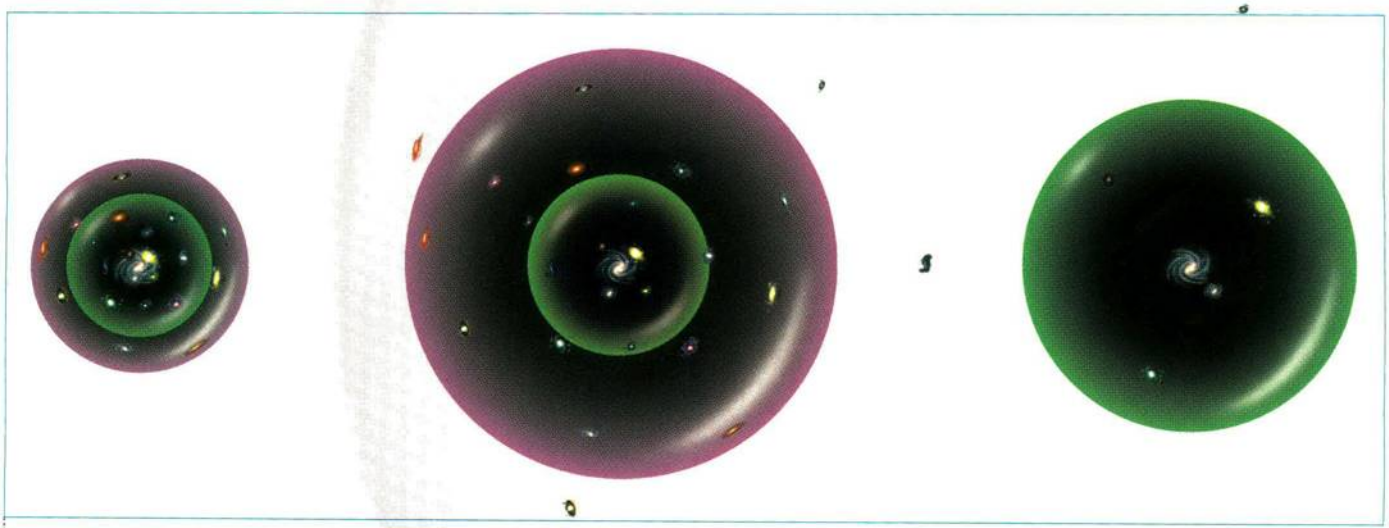
Caveats, of course, apply to all speculation about the distant future — the further in time we go, the greater the uncertainty. "Any forecasts we make are predicated on the laws of physics remaining unchanged," says Adams. "You can't do anything without that article of faith. But once you know the laws of physics, assuming they don't change, you can go pretty far."

One hundred billion years is, admittedly, a long time, but it's no longer than the projected life span of the longest-lived main sequence stars. And, as Loeb points out, a factor of 10 increase over the universe's current age is not a major change for physicists. University of Pennsylvania cosmologist Max Tegmark agrees that a 10-fold extrapolation "does not take a wild leap of faith. But it doesn't mean things will keep that way forever. Eventually, dark energy may decay causing the universe to contract again."

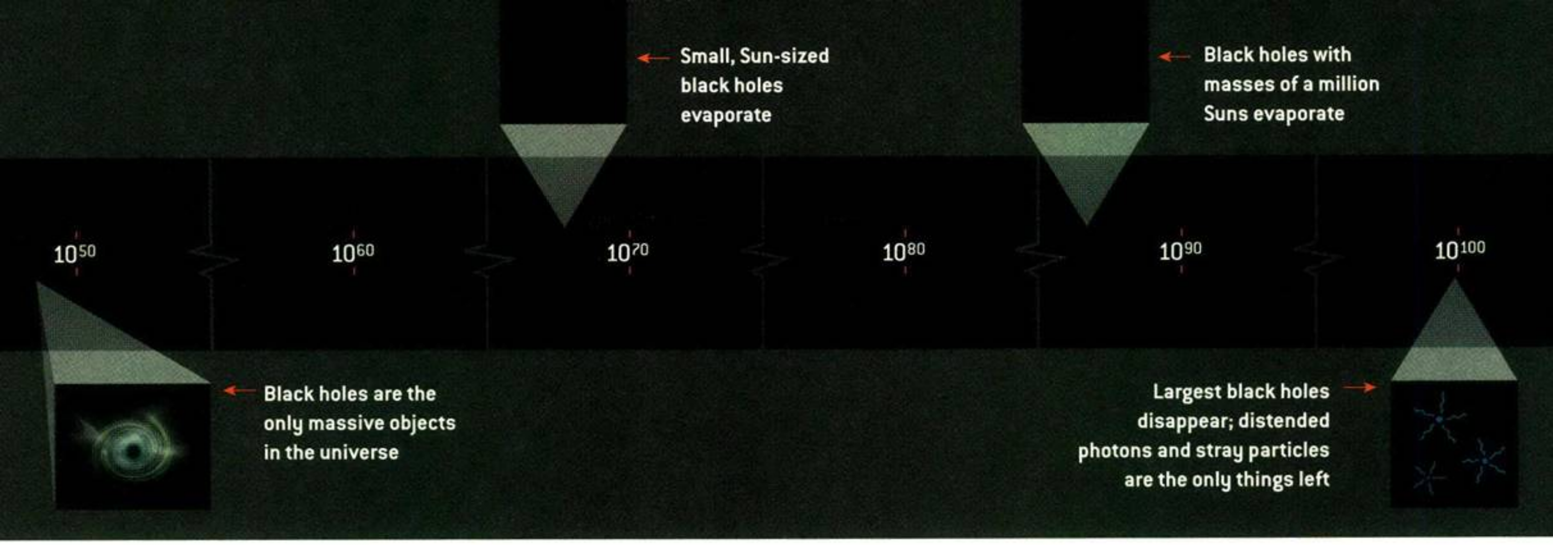
Questions about the nature of dark energy are paramount. The calculations of Adams, Evrard, and Loeb assume that the energy filling the vacuum has a constant value — a so-called "cosmological constant," as Einstein once posited. But if dark energy varies over time, as well it might, the whole picture changes. In view of this fundamental uncertainty, how confident can we be in extrapolating an accelerated expansion into the indefinite future?

Saul Perlmutter, an astrophysicist at the Lawrence Berkeley National Laboratory and the leader of one of two teams credited with discovering cosmic acceleration, believes that key parts of the story are still missing. To the standard inflationary universe model, he says, we've already added dark matter and dark energy. "If you add enough things like that, you have to wonder whether you really understand this picture," he says.

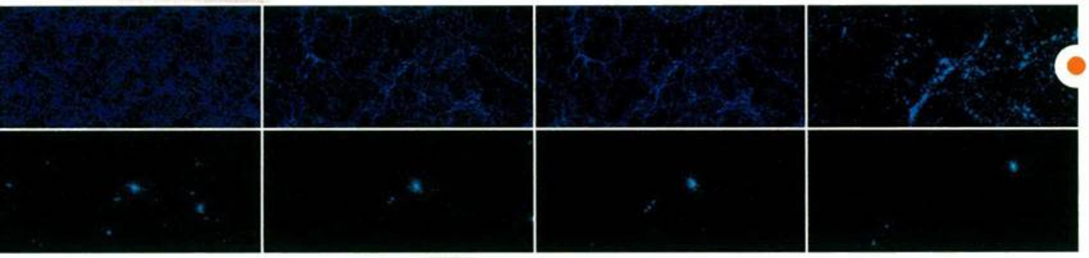
The cosmological constant, although still not understood, is the simplest explanation for cosmic acceleration. But alternatives such as quintessence — a hypothetical form of matter that



DARK ENERGY will expand the universe, but not our horizons. Because light travels at a finite speed, only the light from galaxies within a certain range has had time to travel to us. As space grows ever faster, what we can see of the universe (green spheres) will represent a diminishing fraction of the whole (purple spheres represent an arbitrary region outside our purview). When the universe is about 10 times its current age, we'll only be able to see objects within a 40-billion-light-year radius. *ASTRONOMY: JAY SMITH*


Small, Sun-sized black holes evaporate
Black holes with masses of a million Suns evaporate
10^{50}
10^{60}
10^{70}
10^{80}
10^{90}
10^{100}
Black holes are the only massive objects in the universe
Largest black holes disappear; distended photons and stray particles are the only things left

eventually decays — have been proposed. “Quintessence doesn’t arise as naturally in our theoretical models, yet many theorists are unhappy with the cosmological constant, as well,” says Banks. The reason for their unrest stems from the fact that a cosmological constant dashes any hopes of formulating a precise mathematical theory of the universe. “If you have enough time, you can measure things with absolute precision, but to do that you need an open universe that grows slowly enough that you can, in principle, measure everything in the universe,” he explains. Cosmic acceleration, however, makes that impossible because so much of the universe will become inaccessible. Laments Banks, “We can still predict things with enough precision that any sane person would be satisfied, but it’s annoying to those of us who seek absolute perfection.”



THE ACCELERATING EXPANSION of space will stretch the cosmic web upon which galaxies cluster to the breaking point. Clockwise from left: Computer simulations show a slice of the universe at eight times (in billions of years after the Big Bang): 2.8, 6.5, 14, 24, 33, 44, 65, and 75. M. BUSHA, R. WECHSLER, F. ADAMS, G. EVRARD/MICH. ACADEMIC COMPUTING CENTER

Carpe diem

Ultimately, we may have to accept the notion of an accelerating universe driven by a cosmological constant, the disappointment of theorists notwithstanding. “If the universe has a constant vacuum energy, it will expand exponentially, and there’s no way to prevent it,” says Loeb. “In the meantime, we should use our telescopes to get as much information as quickly as we can.”

“We need to make the best of our brief moment in the Sun,” agrees Krauss. The recent recognition of an accelerating universe won’t call for a fundamental shift in astronomical priorities — a steady push to see farther and deeper into the sky — “but now there’s an even greater urgency. This should inspire astronomers to make every day more useful.”

The perspective provided by the futuristic calculations of Adams, Evrard, Loeb, Krauss, and others can help us appreciate that we live in what Tegmark calls “the golden age of astronomy.” There were far fewer sources to see when the universe was a fraction of its current age, and fewer still will remain within view as the universe splits apart into isolated enclaves.

Yet upon contemplating where cosmic acceleration will take us, some investigators find the prospects disheartening. A universe dominated by a cosmological constant is “the bleakest of all outcomes, offering no chance to do cosmology, no chance for rebirth — just a long cold death,” according to Brian Schmidt, an astronomer at the Australia National University who heads the second observational team credited with the dark energy discovery. There’s no long-term future in an accelerating universe, adds Krauss, as civilizations (along with life of any form) are ultimately doomed and knowledge destined to be forgotten.

Banks takes issue with such views, dismissing them as “the ultimate in hubris. We’re a minor phenomenon in the cosmos and imagining that we could be here forever is silly,” he says. “We’re here for a brief time in the lifetime of the universe, and we should enjoy it while we can.”

In looking ahead trillions of years from now, Adams doesn’t consider the future dismal at all. On the contrary, he says, “I find it empowering that we can understand the laws of physics well enough to make statements about what will happen in a trillion years with some confidence.”

Until cosmic acceleration gained acceptance, the previously favored scenario — an expanding universe that decelerates over time, slowly approaching a halt but never getting there — led to what Evrard considers a “boring” conclusion. “Now it seems we’re headed to another, more dramatic end — a rocket ride,” he says.

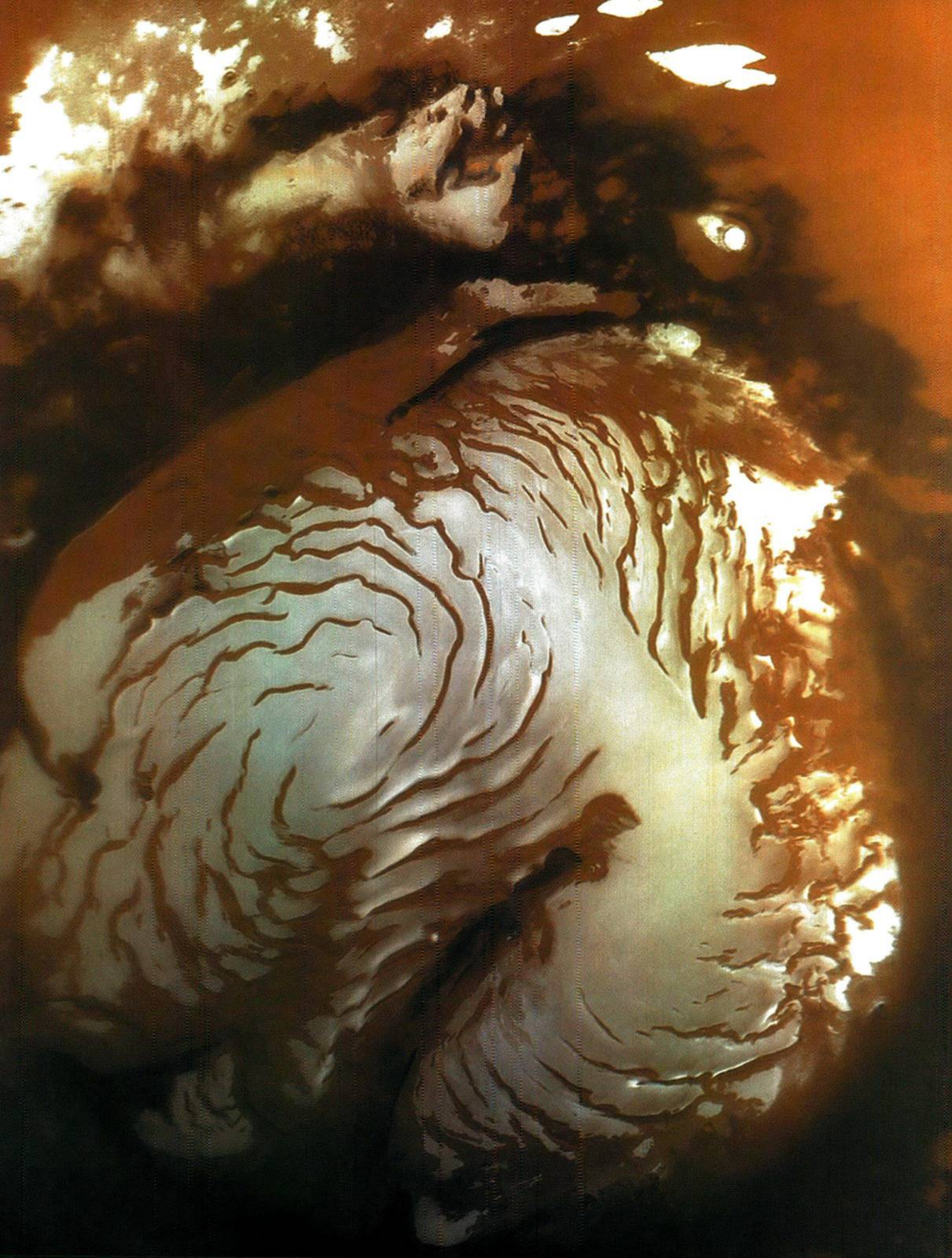
That’s one way of describing our fate, but it might also be put in other, less appealing terms: a faster-than-expected trip to oblivion. To all you passengers out there, the “fasten seatbelt” lights are now flashing. Sit back, buckle up, and enjoy the ride. ■

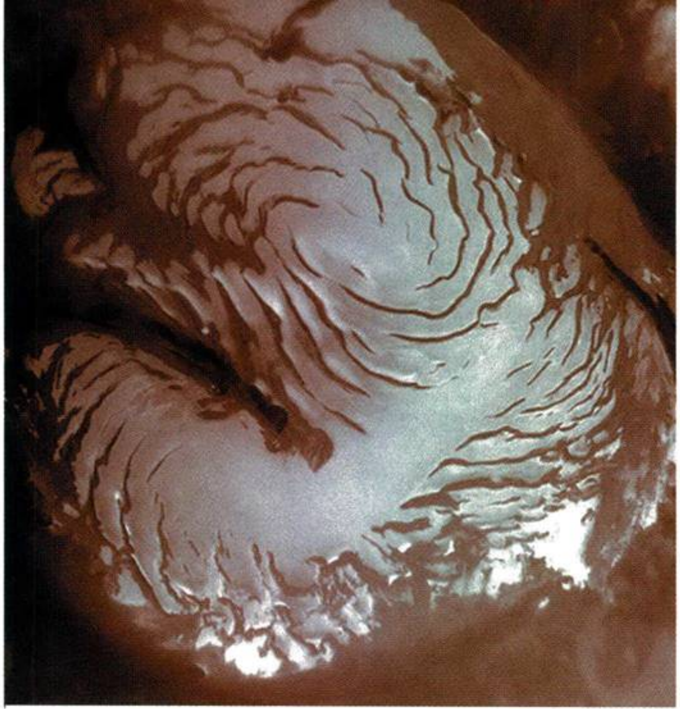
Mysteries of the martian poles

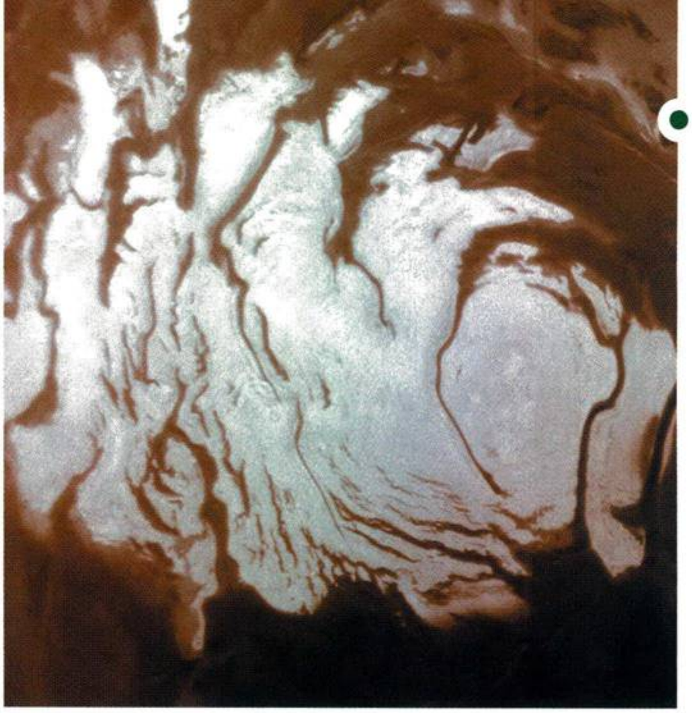
Embedded in the martian polar regions may lie a history of the planet's ancient climate — but unlocking it won't come easy. /// BY PETER THOMAS

In 1911, Norwegian explorer Roald Amundson, three other men, and their dog teams raced across Earth's Antarctic mountain ranges and the ice sheet to reach the South Pole. They narrowly beat a British team led by Robert Scott, who died, together with all his men, on the return journey. ☾ Less than a century after these epochal trips — the last great expeditions into the truly unknown — modern planetary scientists know far more about the martian polar caps than geoscientists knew about Earth's arctic and antarctic regions in the days of Amundsen and Scott. ☾ It once took appalling hardship and immense personal bravery to slowly draw knowledge from Earth's polar regions. Today, interplanetary polar explorers utilize the cool scrutiny of orbiting robotic spacecraft to collect mountains of data. In the last few years, Mars Global Surveyor and Mars Odyssey have helped rewrite the book on the Red Planet. With every new piece of understanding their images have provided, however, they have also posed myriad questions. Deciphering the surface features of Mars will be one of geoscience's greatest puzzles for the next several years.

THE SOUTH POLAR CAP of Mars covers a region nearly 3,000 kilometers wide in this color mosaic. The bright region is permanently covered by carbon dioxide ice. Extensive layered deposits surround this ice cap. NASA/LPI







MARS'S NORTHERN POLAR RESIDUAL CAP (left) and polar layered deposits stand out in this composite image of several MOC frames. This image covers an area 690 miles (1,100 km) wide. The spiraling dark areas are troughs that expose the layers. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

MARS'S SOUTHERN POLAR RESIDUAL CAP (right) appears white in this summertime image. The layered deposits, which appear as dusty colored terrain, extend well beyond the 315 mile (500 km) -wide area in this image. COMPOSITE IMAGE OF SEVERAL MOC FRAMES, NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

Heaps of dirt and ice

Polar regions represent more than opportunities for adventure. They also contain an environmental record of a planet's climatic history. Using terrestrial ice core samples, scientists have studied long-term temperature and moisture cycles that define our planet's climatic trends. As scientists look to the Red Planet, they see in its polar regions the information necessary for evaluating the mechanisms that have modified Mars's surface. They want to unravel its climate and seek past environments that may once have supported extraterrestrial life (and may still). As planetary scientists optically dig through millions of years of layered polar ice and dust, it is becoming clear that Mars is in the process of a climatic reversal.

Mars's distinctive polar caps have long been evident to earthbound observers. Clearly visible even in modest telescopes, the cyclical growth and contraction of Mars's ice caps have captivated generations of planet-watchers. Real understanding of the caps, however, wasn't possible until the Space Age gave us a close-up view. Starting in the 1960s, spacecraft have steadily revealed a parade of surprising martian features and geological mysteries. Prime among these have been the polar caps.

To visualize the martian polar regions, imagine a plate heaped with paper-thin pancakes liberally dusted with powdered sugar. Translated into martian terms, the "pancake stack" displays three basic features: a base of layered ice, dirt, and dust; a permanent frost or ice layer; and a seasonal layer of frozen carbon dioxide. The base layer can be up to 2 miles (3 km) thick and is cut by deep troughs that often spiral outward. This permanent base layer and its constant covering of frost and ice form the residual caps and layered deposits.

The seasonal covering of frozen carbon dioxide is a winter affectation that can extend as far toward the equator as 45° latitude. Over the past several years, Mars Global Surveyor has provided freeze-framed movies of the seasonal formation and sublimation (transformation of the ice back into gas) of this layer. Surprisingly, the net amount of ice formed each year appears to be shrinking, and this has dramatic consequences for the martian atmosphere.

This layer of carbon dioxide frost, or dry ice, precipitates from the atmosphere each fall. The martian atmosphere is 95 percent carbon dioxide and the freeze-out deposits approximately 25 to 30 percent of the entire atmosphere at the poles. Depending on its "fluffiness," the seasonal covering has a maximum depth of roughly 3 feet (1 meter). In spring, rising temperatures cause the ice to sublimate and return to the atmosphere — for a while, at least. As spring warms one pole, autumn icily descends upon the other, and the recently liberated carbon dioxide is frozen back out of the atmosphere to coat the other hemisphere. The martian atmosphere temporarily stores the seasonal covering as it migrates endlessly from pole to pole with the turning of the seasons.

As scientists monitor the seasonal polar caps using thermal and visual observations, they have discovered complexities in the caps' growth and decay. The seasons on Mars vary in their intensity from pole to pole in ways that are different than we find on Earth. This relates to differences in the planets' orbital elements. Mars is more tilted, and its orbit is more elliptical. During the southern winter, Mars is at its farthest from the Sun and orbiting slowly. This causes the southern winter to be longer than the northern, and the southern seasonal covering to be thicker. Over time, Mars's orbit and tilt are slowly evolving, and with this the polar regions are reshaping themselves in dramatic ways.

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Reading the book of obliquity

Mars's layered deposits — the bottom of the pancake stack — demonstrate rhythmic changes in the way ice and dust accumulate at the poles. High-resolution images of trench walls show alternating light and dark bands representing ice with varying dust concentrations. These variations show the evolution of the martian climate — changes in storm intensities, variations in atmospheric deposition amounts, and changes in the amount of sunlight — over a period of several million years. Erosion is apparent between some layers, and this indicates past interruptions in the growth of the polar caps. Currently, the polar caps are again shrinking, and there is no evidence that this trend will reverse. The switch from deposition — growth of new layers of ice — to erosion suggests a change in the martian polar environment.

The residual layers lack visible craters, indicating that the polar regions are geologically young features. Combined with the apparent modern erosion of the polar caps, this suggests that something happened to Mars's environment within the last few tens of millions of years that created the layered deposits. More recently another change occurred, causing the polar deposits to start eroding.

To understand such geologically fast changes, scientists look for variations in the planet's orbit and axial tilt. Earth's orbital tilt, or obliquity, is stabilized by the gravitational tug of our Moon. Mars, lacking a satellite with significant mass, is free to vary its obliquity from 15° to 30°. Currently, it is inclined 25.1°, which is close to Earth's value (23.5°), but that's just a passing coincidence. Simulations show that Mars's orbit and tilt cyclically change. Changes in the planet's obliquity will affect the amount of energy the poles absorb from the Sun and will result in a rhythmically varying climate.

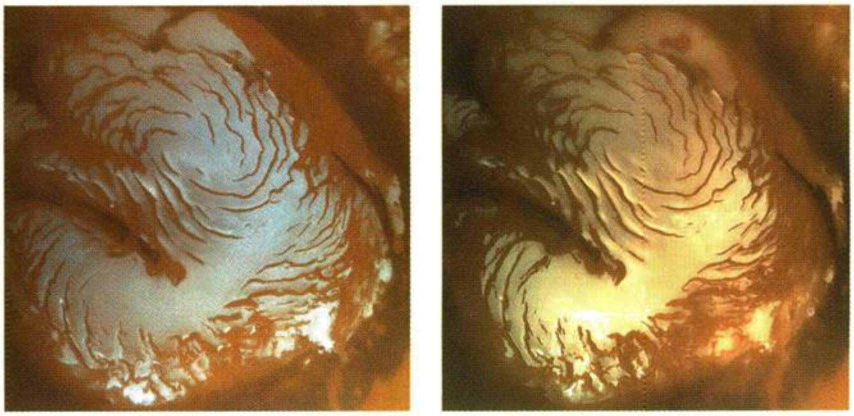
For scientists, it's enticing to connect variations in the polar deposits with astronomically driven phenomena. Such a link can yield timescales for polar and global events and establish climate variation. Unfortunately, making such connections can be very messy.

The first problem is simply measuring the layers and following them through the landscape. On an otherwise smooth slope, a layer may form a ridge or a trough. A layer's apparent thickness partly depends on how it weathers, rather than just how thick it was when created.

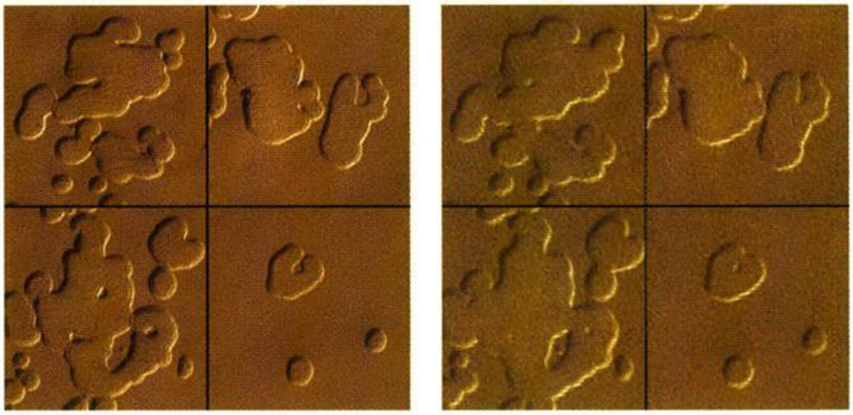
The secondhand nature of satellite imaging creates its own difficulties. Separating topographic shadows from dark-colored material isn't always easy, especially since the surface appears to be rough on scales of a meter or two. The exposed layers are much darker than pure ice or frost and probably contain deposits of dust or mineral grains left behind as the ice sublimated. This is similar to the dark residue of pollution and sand apparent in partially melted snowbanks along roadways. The lower parts of the northern layered deposits, in fact, appear to contain a great deal of dark material. Debris from sublimated ice has formed sand dunes near where the layers are eroding (see page 50).

Recently, scientists working with topographic data from the Mars Global Surveyor's laser altimeter compared high-resolution images of the layers in a single trough with predictions of how layer thickness should relate to astronomical cycles. They found agreement between their theories and their observation. If this correlation is generally applicable, then the polar ice layers formed at rates of less than one-tenth of one millimeter per year, and the entire stack of layers formed over tens of millions of years. This is a long time in human terms but still short compared to the 4.5-billion-year age of Mars.

/// CHANGING SURFACE FEATURES



DETAILED FEATURES IN THE EVOLVING POLAR ICE, imaged by the Mars Global Surveyor, change from season to season and year to year. The left-hand image was taken in March 1999, while the right-hand image dates from January 2001. The martian poles evolve with the changing seasons and may be currently shrinking. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS



SMALL HILLS VANISH AND PIT WALLS EXPAND on Mars during the years between these images (left: 1999; right: 2001). The pits are formed in frozen carbon dioxide, which sublimates a little more each year. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

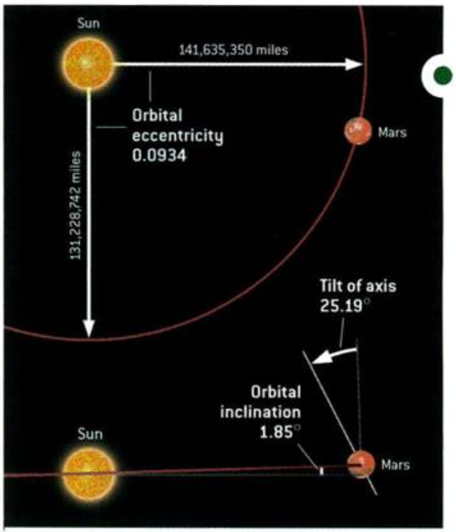
One problem in connecting variations in the polar layers to astronomical events is the fact that orbital and spin histories of Mars are not precisely known. Scientists' ability to calculate the orbit and axial tilt of Mars degrades as they push their models farther back in time. If the exposed polar layers were created during recent cycles — the last few million years — then models may be reasonably accurate. If those deposits are tens of millions of years old and have been recently exposed by erosion, then any connections made to astronomical cycles refer to generalized events — to random periods of global cooling or exaggerated orbital tilt — rather than to specific points in Mars's orbital evolution.

Poles apart

Significant differences exist between the northern and southern residual polar caps. The northern residual cap covers nearly all the layered deposits and is composed of water ice, while the southern residual cap is smaller and composed mainly of dry ice.

The puzzling differences between the residual ice caps taken with the apparent similarities in the seasonal layers pose a general question: Do today's residual caps let us connect what is happening now to the formation of the layered deposits? In other words, how, if at all, do the present caps relate to the layers underneath?

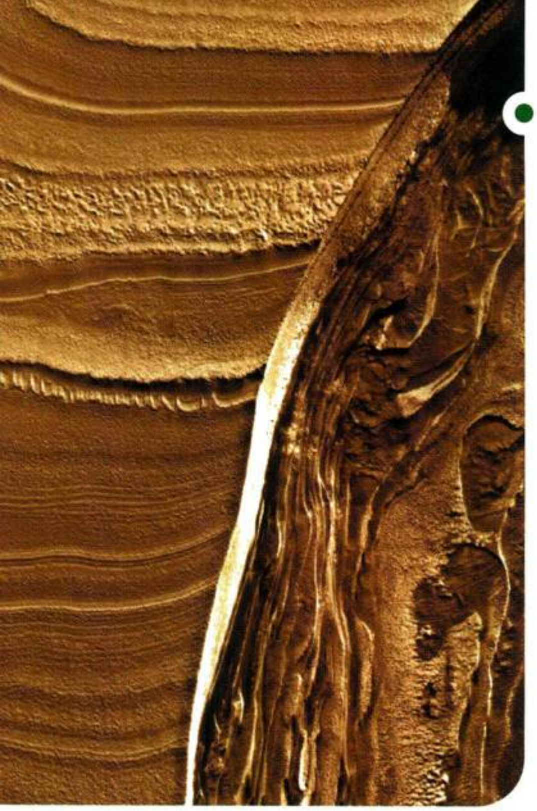
One of geology's core principles is that present-day processes and forms can help interpret the past. One obvious use of this principle would be to tie present-day deposition rates with the stack of layered deposits to determine their ages and history. Seasonal coatings come and go, but if the residual caps represent present-day deposition, can studying their formation and modification help link the present to the past?

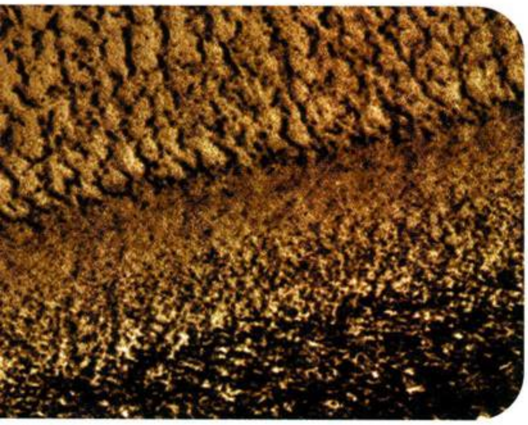


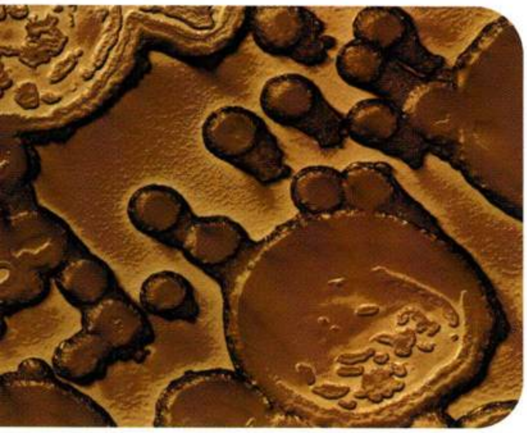
MARS IS TILTED at a larger angle than Earth, and its orbit is more elliptical. During the northern summer, Mars is noticeably closer to the Sun. Consequently, the seasons in the northern hemisphere are significantly more severe than in the southern hemisphere. March is the peak of summer at the northern pole. *ASTRONOMY*: ROEN KELLY

The northern residual cap appears to grade into the layers beneath. Most of this area, imaged in summer with sublimating water frost on its surface, has a locally rough and pitted texture with relief of 6 to 10 feet (2 to 3 meters). Virtually the entire northern residual cap has some version of this pitting. At the interface between this and the exposed layers, the two seem to merge smoothly. Thus the northern residual cap, taken as a snapshot of present-day polar processes in action, shows small, slow deposition. It also hints that no major time gap exists between the residual cap and the continued creation of layered terrain.

Turning to the southern polar cap, the picture abruptly grows complicated, making an easy global view impossible. The southern residual cap displays a bizarre topography not seen anywhere else on Mars (see page 49).







[TOP TO BOTTOM] **A HISTORY OF THE MARTIAN CLIMATE** is stored in the layers of the northern polar deposits. This image shows a small part of one of the dark spiraling troughs shown on page 50. Layers on the left are exposed on a gentle slope, which is cut by a steep, 30-degree scarp on the right. The scarp is made primarily of ice but also contains a lot of sand. As the scarp erodes and is sublimated in spring, the dirt that had been in the ice is left behind. The wind gathers this debris into dunes a few kilometers away. The features in this image are 1.5 km wide. MOC E02-02460, NASA/JPL/MALIN SPACE SCIENCE SYSTEMS **PITS AND CRACKS** in the northern residual cap grade into the layers below. This image shows a region 0.45 miles (700 m) wide. MOC M00-02072, NASA/JPL/MALIN SPACE SCIENCE SYSTEMS **FROST-COVERED CIRCULAR DEPRESSIONS,** some elongated by wind erosion, pox the southern polar residual cap. MOC M12-00161, NASA/JPL/MALIN SPACE SCIENCE SYSTEMS **"FINGERPRINT" PATTERNS** of depressions and other exotic ice formations distinguish Mars's southern polar residual caps. These depressions are only a few meters deep. MOC M03-06756, NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

Instead of a pitted surface, the southern residual cap has shallow coalescing depressions cut into a thin few layers of material. Each layer is perhaps 10 feet (3 meters) thick, giving the depression a total depth of about 40 feet (12 meters). Some depressions are circular, with small central mounds. Other depressions form spirals, arcs, nearly parallel troughs called fingerprint terrain, or long, worm trail-like depressions. The vertical relief on these structures is only a few meters, and widths typically run less than 70 feet (200 meters). The uppermost surface has large polygonal cracks that suggest long-term cycles of warming and cooling. Unlike its northern sibling, the southern residual cap appears to be distinct from its underlying layered deposits.

Caught in the act

So what's going on? The observed association of unusual topography with carbon dioxide ice may be an answer. Dry ice is more volatile than water ice, and geological differences between the caps may result from sublimatation differences.

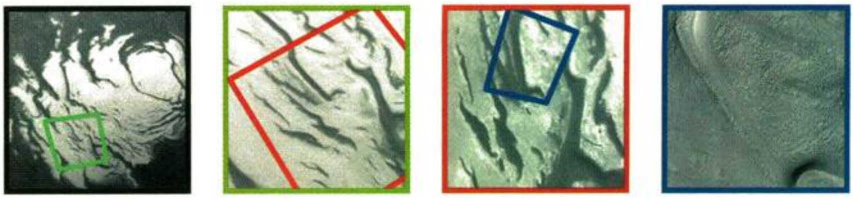
The longevity of the Mars Global Surveyor spacecraft (1997 to present) has allowed unprecedented long-term studies. Over the course of one year, the scarps and bumps in the martian landscape don't just sublimate in summer and re-deposit in winter, with no net change. Instead, they are receding at rates up to 13 feet (4 meters) a year. This implies a net transport of carbon dioxide from the residual cap's ice back into the air. Mars's atmosphere is steadily (if slowly) becoming denser. We may be catching martian climate-change in the act.

These changes haven't been noted in the north, and because water ice sublimates much more slowly, scientists don't expect to see significant changes given the limited resolution of current spacecraft cameras. Observational evidence of ongoing changes in the north will have to await future missions.

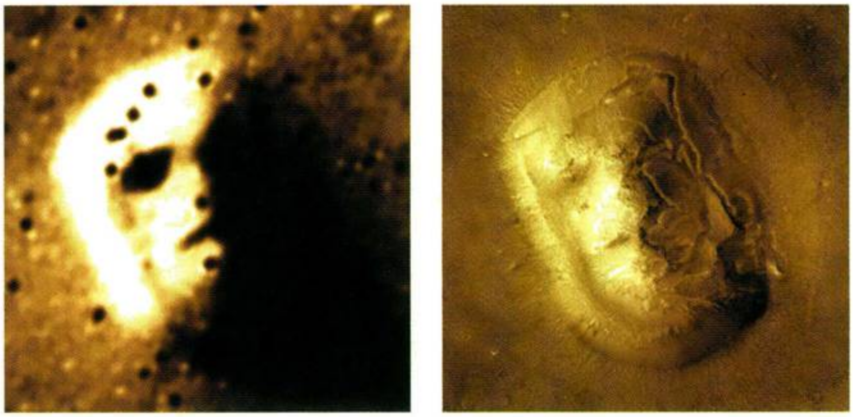
Just as the condition of Earth's polar caps define and are defined by planetary weather patterns such as global warming, so, too, are the martian polar regions part of a complicated climatic weather feedback loop. Conditions elsewhere on the planet must be factored into interpreting the poles, and vice versa. The incredibly detailed images of the main camera on the Mars Global Surveyor have revealed sites outside the polar regions where volatile-driven phenomena occur, such as possible seeps in canyon walls and freeze-thaw ground cracks.

Of crucial importance to understanding martian climatic evolution is the geography of ice lying at or near the planet's surface. This water not only affects weather models, but it may be crucial to the survival of future explorers. Here the Mars Odyssey mission (2001–) recently made a major find. It has detected hydrogen, almost certainly in the form of water ice, close to the surface in many places. In the higher latitudes, nearly half the volume of the near-surface layers could be water ice. Encouragingly, the ice appears where current martian climate predictions say it should be stable. This important finding will help water vapor motion models be fine-tuned.

/// IMPROVING RESOLUTION



A MOSAIC OF VIKING ORBITER IMAGES shows a region on Mars about 250 miles (400 km) across. These images provided earthbound humans a first close-up view of Mars. NASA **THE VIKING 2 ORBITER** (green outline) could discern cracks and ravines in the polar ice. Images like this have resolutions of 568 feet (174 meters) of ground per pixel. NASA **MARINER 9 IMAGES** (red outline) showed 327 feet (100 meters) of martian surface per pixel. With each new mission, NASA improved its technology and enhanced our view of Mars. NASA/JPL **MARS GLOBAL EXPLORER,** (blue outline) the current imaging mission, provides unprecedented resolution with its orbital camera. In this image (MOC 7709) each pixel represents just 167 feet (50 meters). NASA/JPL/MALIN SPACE SCIENCE SYSTEMS



VIKING GAVE US OUR FIRST GOOD LOOK AT MARS — and Mars looked back. At the low resolution of Viking, this set of hills in partial shadow eerily appears to be a perfectly sculpted face. NASA/JPL **IN THE AGE OF MARS GLOBAL SURVEYOR,** the "Face on Mars" has been reduced to a run-of-the-mill hill. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

The 21st martian century

As the new century gets underway, scientists have assembled part of the martian polar puzzle, but many mysteries remain. What makes the northern cap so different from the southern cap? Is elevation important? Have the layered deposits undergone significant glacier-like flow, as is seen in Antarctica? Scientists need better three-dimensional mapping of layers to answer these questions.

The dramatic geological formations also raise more questions than they solve. For instance, what carved the deep spiral troughs in the layered terrain? Dedicated missions to study the polar deposits and observe the annual weather-cycle at ground level are essential for reading the full martian polar story. Until scientists unravel the polar environment, our understanding of Mars's climate will remain incomplete.

Way too Cool

Created in a recent supernova explosion, a young neutron star reveals secrets of nuclear matter. /// BY DAVID HELFAND

Early one August evening in A.D. 1181, "*a guest star appeared in Kui lunar lodge. It was trespassing against Chuanshe. According to the divination, the guest star was a star of ill omen.*" ☾ So begins a story that in 2001 led to newspaper headlines around the country: "Weird Stars Show Evidence of a New Form of Matter" and "X-ray Telescope Finds Stars That May Defy Current Physics." I'm happy to report that current physics remains comfortably intact. But close examination of the detritus left behind by the celestial visitor of 1181 is providing some tantalizing clues about the structure of the subatomic world.

Astronomers from the Song dynasty in southern China were not the only ones watching the sky for portents in the 12th century. Observers from the Kamakura Shogunate in Japan left two records of the new guest star, dating its appearance to August 7. One record compares its brightness to Saturn and states that it is the first brilliant "guest" since one recorded 175 years earlier. In a Jin dynasty report from northern China, we read that the new star was visible for 156 days, "*... then it was extinguished.*"

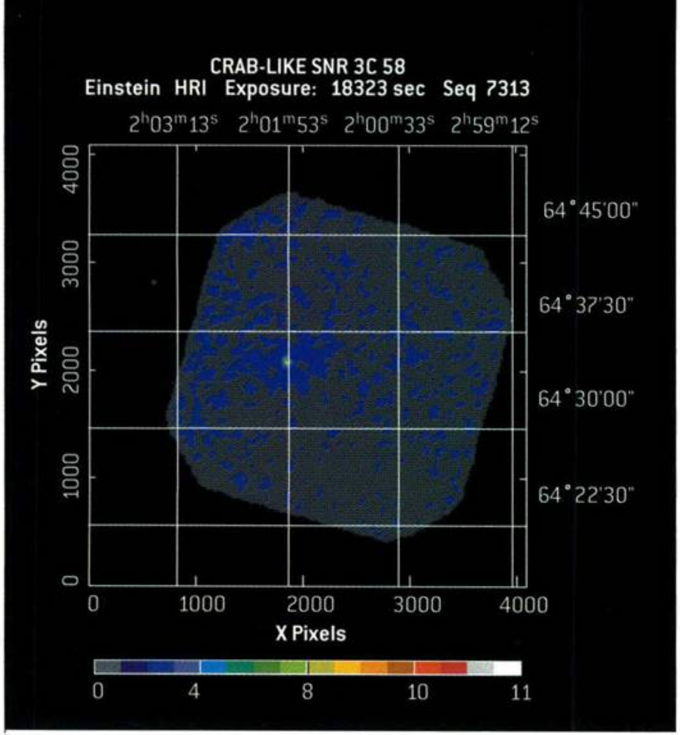
Extinguished to the naked eye perhaps, but hardly gone. At the site of the explosion, the collapsed core of the parent star was spinning rapidly, pumping out enormous amounts of energy to build a surrounding nebula. Meanwhile, under the surface of the stellar core, forms of matter never seen on Earth were taking shape.

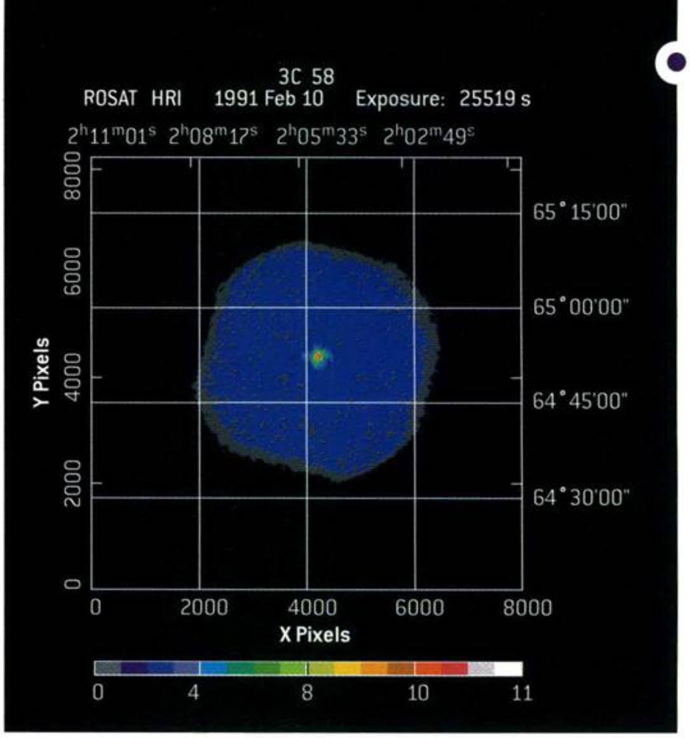
Eight hundred and twenty years later, the secrets of this matter are beginning to be told.

Radio astronomers were the first to record a signal from the guest star's location when they listed it as the 58th entry in the *Third Cambridge Catalogue* of radio sources in 1959. Nearly two decades later, Andrew Wilson and Kurt Weiler studied 3C 58 in detail. They suggested it shared several properties with the most famous guest-star remnant — the Crab Nebula — which formed after the destruction of a massive star in a supernova explosion, witnessed around the world on July 4, 1054.

The Crab is one of the most studied objects in the sky — the subject of more than 2,000 research papers since 1950 — and is the Rosetta Stone for decrypting

SITTING AT THE CENTER of a maelstrom it helped create, the pulsar in 3C 58 spins slower and appears denser and cooler than expected for a neutron star. ASTRONOMY: ROEN KELLY





OUR FIRST DECENT LOOK AT 3C 58 (left) came from the Einstein Observatory, although it couldn't resolve the central pulsar. NASA/GSFC

ROSAT YIELDED BETTER RESOLUTION and much higher sensitivity (right), yet the pulsar remained tantalizingly out of reach. ROSAT DATA CENTER

the fate of massive stars. Briefly, the standard story goes like this:

Having run out of nuclear fuel, the core of a massive star suddenly implodes, creating a dense, spinning neutron star. The energy released in the collapse causes a titanic explosion, hurling the star's outer layers into space. The rapidly rotating neutron star has a huge magnetic field and acts like a giant generator, pouring a current of particles traveling at nearly the speed of light into the surrounding nebula, making it glow. The star itself flashes a lighthouse-like beacon in our direction with each rotation, justifying its name — a pulsar.

As astronomers find more remnants of massive stars, the details of the picture are changing. Moreover, the prototype object, as often happens in astronomy, is turning out to be less and less typical of the class. But the basic picture remains unchanged and provides a useful outline for the story of 3C 58.

Cousin to the Crab?

My own involvement with the Guest Star of 1181 began more than twenty years ago, around its 800th birthday. Using the first x-ray telescope, the orbiting Einstein Observatory, we targeted 3C 58 with the observatory's cameras and spectrographs to test the hypothesis that it was a twin of the Crab Nebula. We also looked for its central neutron star.

The x-ray spectrum of 3C 58 showed lots of high-energy photons compared to low-energy ones and an absence of features expected from hot x-ray gas. These were just the characteristics expected for a Crab-like emission of electrons spiraling in nebular magnetic fields almost at lightspeed. Furthermore, the x-ray brightness peaked at the center of the remnant, suggesting a central power source. Kinship with the Crab looked promising.

There were two striking differences, however. The total x-ray luminosity was 2,000 times weaker, and the x-ray nebula extended several times larger. In addition, our search for a central pulsar was unsuccessful. The highest quality camera on Einstein had a resolution equivalent only to binoculars, so we couldn't resolve the central star from the surrounding nebula.

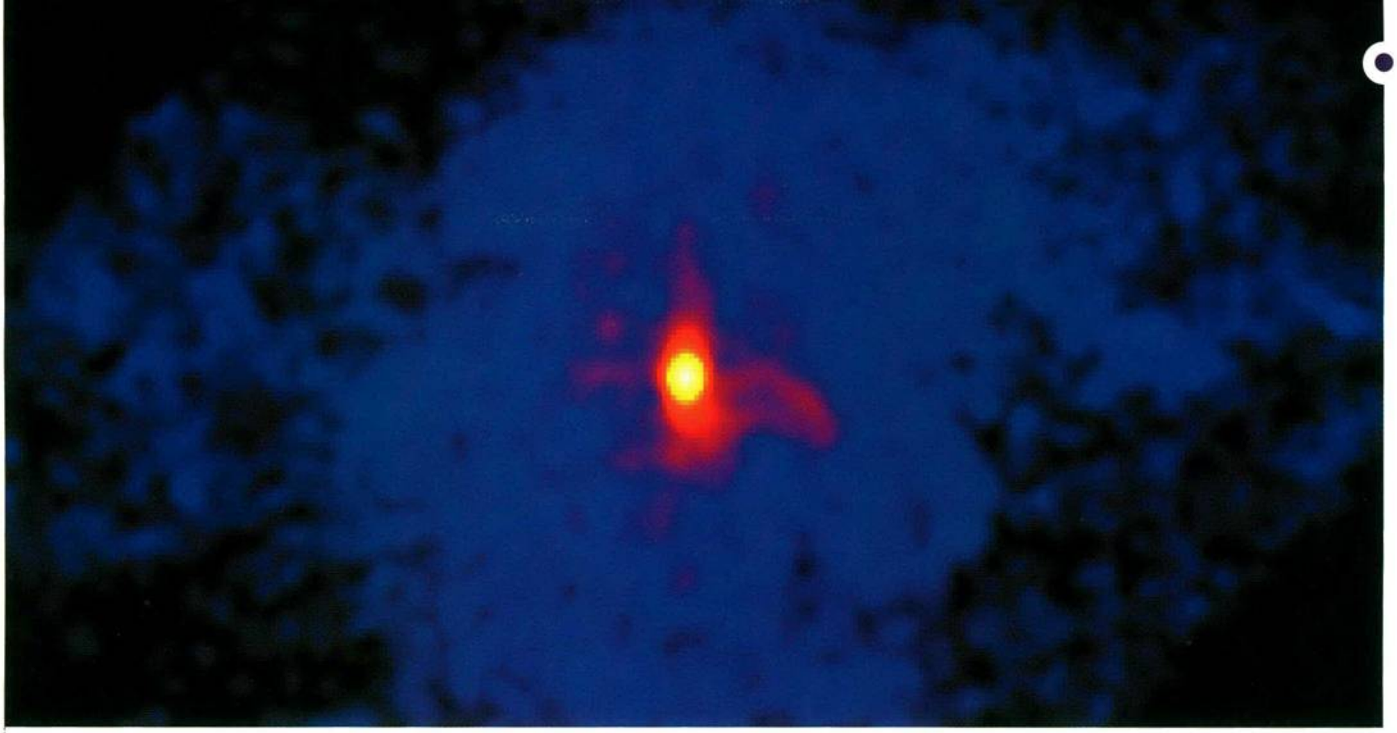
Ten years passed. In 1991, we used the German x-ray satellite, ROSAT, in another attempt to find 3C 58's pulsar. ROSAT's High Resolution Imager had slightly better resolution and considerably higher sensitivity than Einstein's. But the result of a seven-hour exposure was again somewhat unsatisfying. In the remnant's core we found a bright concentration of x-ray emission, but it appeared extended north to south. Unfortunately, a small fraction of ROSAT observations were plagued by an error in the star-tracking cameras that turned point sources into blobs just like this. Because we couldn't rule out this explanation, we were left with an ambiguous result. We tried searching for a period in the arrival times of the 352 x-ray photons making up the blob, but found nothing significant.

Another decade passed. Then the Chandra X-ray Observatory, x-ray astronomy's equivalent of the Hubble Space Telescope, was launched. On September 4, 2000, my colleague Pat Slane at the Harvard-Smithsonian Center for Astrophysics slipped our previously approved observation of 3C 58 into the Chandra schedule. That day we collected nearly ten hours of good data with Chandra's Advanced CCD Imaging Spectrometer camera. Nine months earlier, Pat's colleague at CfA, Steve Murray, had used Chandra's other camera (which he had built) to observe 3C 58. But in the flood of data pouring in daily, the dataset remained unanalyzed.

And we weren't much faster. Then on March 28, 2001, I got an e-mail from Pat:

"I finally got a bit of time to get back to the 3C 58 data. I'm working on it now, and plan on spending more time tomorrow. An encouraging result from today, that I need to quantify, is that there definitely seems to be a point-like source in the compact inner nebula (by which I

David Helfand *is Chair of the Astronomy Department at Columbia University, where he has taught and conducted research for the past 25 years.*



THE RAPIDLY ROTATING PULSAR IN 3C 58 came into view as the bright spot in the center of this Chandra X-ray Observatory image. It lies embedded in extended emission produced by energetic particles accelerated to nearly the speed of light by the pulsar's enormous magnetic field. NASA/CXC/CFA/P. SLANE ET AL.

mean the extended object that we used to consider a point source — but that you concluded *might* be extended based on the ROSAT data). Have a look."

It took me three seconds to download the image from his website, five seconds to run down the hall to the printer, and less than a minute to show it to colleagues at Columbia who share my interest in dead stars. All agreed it was a good bet that the pulsar in 3C 58 had at last been found. Unfortunately, this Chandra camera takes three-second-long exposures, so there was no chance to look for the pulsar's spin period (which was expected to be much less than one second).

But Steve Murray's camera records the arrival time of each x ray to an accuracy of millionths of a second, and as soon as Pat showed him our picture, their analysis sprung into high gear. Within days, they found an x-ray pulse with a period of 65.7 milliseconds, roughly twice that of the Crab pulsar. A comparison with data obtained earlier by the Rossi X-ray Timing Explorer mission showed that, like all pulsars, this period was slowly lengthening as the star lost energy to the surrounding nebula. This stellar dynamo was pumping out energy at a rate nearly 100,000 times that of the Sun. The inferred magnetic field strength, roughly 10 trillion times that of Earth's, was very similar to that of the Crab pulsar.

The match to our standard supernova story was nearly perfect. 3C 58's only major difference from the Crab was the initial spin rate of the star. Knowing the age, the current period, and the rate at which the period is slowing, we can calculate the spin period at birth. For the Crab, it is 19 milliseconds, while for 3C 58 it is closer to 60 milliseconds. Now, the shorter the period, the higher the spin rate. And the higher the spin rate, the more energy is available for powering the nebula — in fact, every factor of two increase in the initial spin rate raises the power by a factor of 16. Thus the slower initial spin of 3C 58 goes a long way toward explaining why it's so faint in x rays compared with its Crab cousin.

The whole picture was coming together nicely.

Although the data were of no use in finding a pulse period, they did record the energy of each arriving x ray. This let us construct a spectrum of the pulsar and its surrounding nebula. And that's where the fun began.

Weird starlight

Astronomers don't "see" most pulsars the way they do other stars — by detecting thermal radiation produced by atoms jiggling on their surfaces. For example, the Sun produces predominantly yellow light because its surface temperature is roughly 5800 kelvins. This means its surface atoms are rushing around at a speed such that collisions between them produce electromagnetic energy at a wavelength of 500 nanometers ("yellow" to our eyes). The atoms on hotter stars move quicker and collide more violently, and produce higher-energy (to us, bluer) light. Similarly, cooler stars have more sluggish atoms and produce low-energy red photons. Astrophysicists have a general rule: The amount of energy a star radiates is proportional to its surface area, and to the fourth power of its surface temperature. Decoded, this means that if two stars have the same surface area, but one

> We got interested in the Guest Star of 1181 around the time of its 800th birthday.

is twice as hot, the hotter star radiates 16 times more energy.

While exotic particles have been produced in atom smashers for fleeting moments, they could live forever in the core of a neutron star.

But neutron stars aren't directly comparable to ordinary ones. Although they are hotter than the Sun, neutron stars are *tiny*, with surface areas only one ten-billionth that of the Sun. The fact that we can see them shining brightly across thousands of light-years, at wavelengths from radio to gamma rays, tells us that they use a totally different radiation process than what makes the Sun shine.

Neutron stars are huge spinning magnets that produce enormous electric fields near their surfaces: 1,000 trillion volts is typical at the magnetic poles. Just as voltage differences between the ground and thunderclouds can produce sudden discharges of lightning on Earth, titanic energy releases on a neutron star's surface rip out particles and accelerate them to nearly the speed of light. These particles (primarily electrons and their sister antiparticles, positrons) spiral around the huge magnetic field of the star, generating continuous radiation that spans the spectrum. It is x rays from this process that Chandra detects as pulses when a pulsar's poles sweep in and out of view with each rotation.

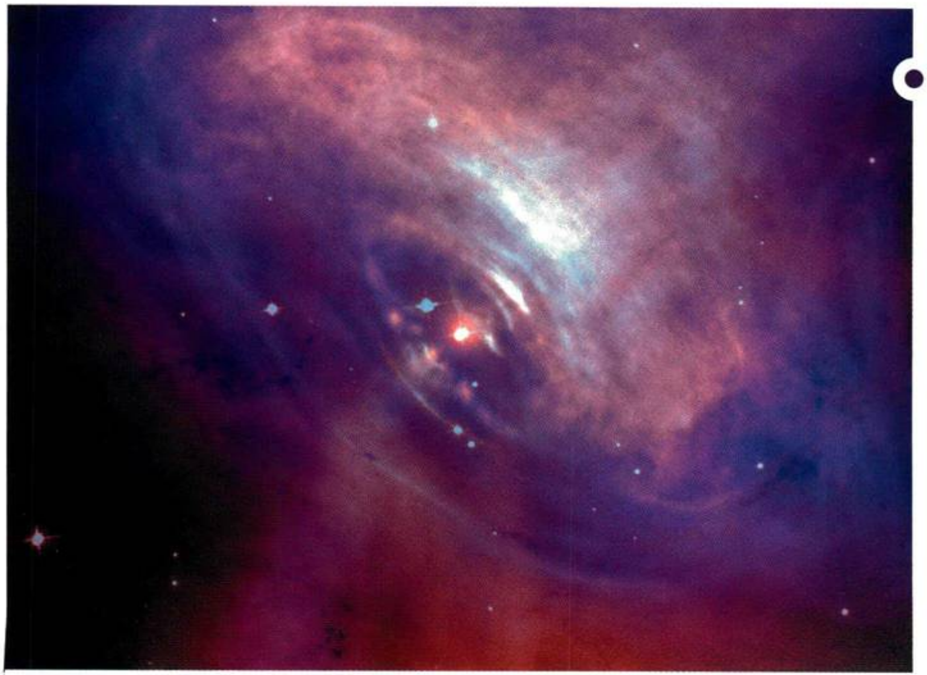
Tiny as they are, neutron stars still have a surface and they are born in a very hot place (a supernova explosion). Thus, we thought, it might not be crazy to look for surface thermal emission — that is, to try to see them as we see other stars.

A newborn neutron star is expected to be hotter than a billion kelvins, and it takes a year or so to cool enough for its surface to solidify. Then, since it lacks any internal heat-producing source (such as the nuclear reactions that drive normal stars), it just continues to cool off, independent of the magnetic and electrical pyrotechnics playing out above its surface. Most of the energy is lost directly from the deep interior, carried away by neutrinos — wraith-like subatomic particles that can travel through a million miles of lead without slowing. Because interacting particles in the neutron star's core produce neutrinos, the rate at which they carry energy away from the star gives us a window on the core.

After 100 years or so, such a star will have cooled to about 3 million kelvins. At this temperature, the surface radiates primarily low-energy x rays at roughly ten times the rate at which the Sun emits yellow light. So despite being small, fresh neutron stars should be detectable at considerable distances. The only problem is, we don't know of any 100-year-old neutron stars. Astronomers expect supernova explosions to create one or two each century in the Milky Way, but we haven't seen a supernova in our galaxy since Johannes Kepler recorded one in 1604. Any that have exploded since then did so far from the Sun, hidden by clouds of dust that block the view of the central Milky Way. Thus, we don't know where to look for hot, young neutron stars. (And even if we did, intervening gas and dust absorb low-energy x rays as efficiently as they do light, so the neutron stars would likely be invisible anyway.)

Neither Kepler's supernova nor one observed by Tycho in 1572 were of a type that leaves behind a neutron star. That makes 3C 58 the youngest known remnant likely to house a hot object. So one of the first things Pat and I did was to look up the expected temperature for an 820-year-old neutron star. The answer was 1.4 million kelvins. We plugged this into software that calculated a likely spectrum and compared that to our data.

The mismatch was absolutely terrible. We were delighted.



THE CRAB NEBULA'S VIOLENT INTERIOR features shock waves and high-speed winds in this composite combining an optical image from Hubble (seen in red) with an x-ray image from Chandra (in blue). The Crab pulsar is the white dot at the center of the image. NASA/HST/CXC/ASU/J. HESTER ET AL.

Extreme matter

The calculated spectrum (see page 59) showed that, sitting on top of a smooth curve of x-ray photons from the magnetospheric light-show, Chandra should see significant additional emission at wavelengths longer than 1 nanometer. And it simply wasn't in the data. The real star was significantly cooler, less than one million kelvins — in fact, we couldn't detect it at all. Conclusion: The theory that predicted temperatures was wrong.

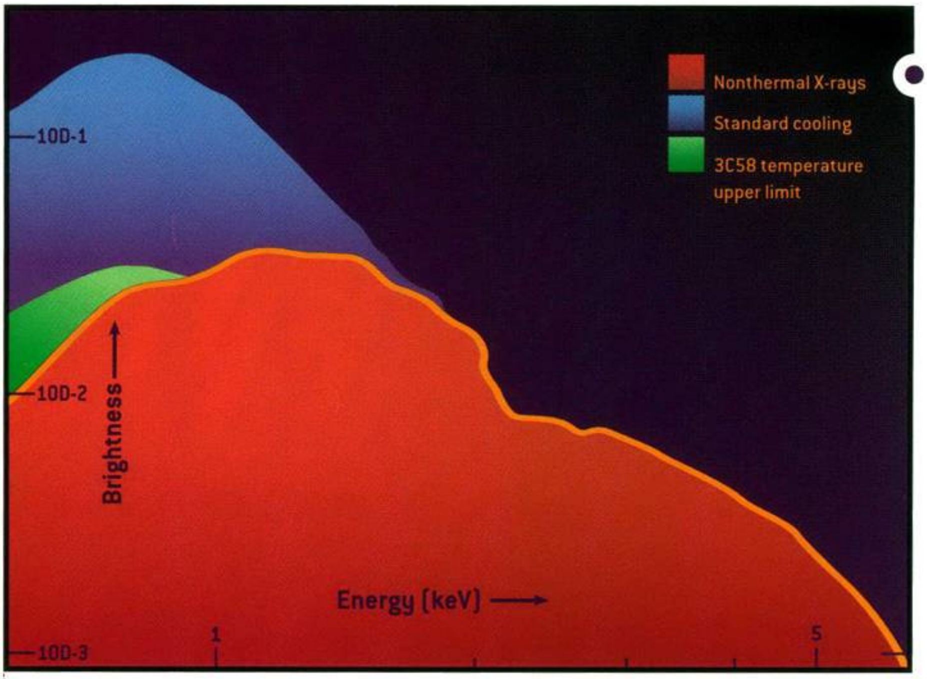
Predicting a temperature for a neutron star of a given age is no easy task. The only things on Earth that even approach a neutron star's density are the individual nuclei of atoms — tiny packages of tightly bound protons and neutrons. The largest of these has 238 nuclear particles packed into a space a trillionth of a centimeter in diameter. That's a density of about a billion tons per teaspoon. Imagine every car and truck on Earth squeezed into a single sugar cube or the entire Earth compressed into a city block.

We don't experience nuclear densities directly because of the enormous distances at which electrons, the third component of atoms, orbit their nuclei. Textbooks commonly show a "planetary atom" as a pea-sized nucleus with electrons spinning around it a few inches away. A real scale-model atom has a nuclear pea orbited by rings of electrons starting 200 feet away. It's atoms like this — 99.9999999999 percent empty space — that make up everything around us.

Nonetheless, by smashing nuclei together, physicists have modeled their internal structure and can predict how they would behave if they were packed together so they touched, with the orbiting electrons out of the way. This is what happens in a neutron star when the enormous pressure of the collapsing stellar core squeezes the electrons right into the nucleus, where they combine with protons to create neutrons. The conversion isn't total, however; depending on the star's mass, up to 20 percent of the matter can remain as protons and electrons, swimming around in a sea of neutrons.

In this environment, when a proton and electron encounter each other, they can merge to form a neutron. Likewise, neutrons can fall apart into an electron plus a proton. In each such transformation, a neutrino (or its antimatter equivalent) is emitted. Undaunted by passing through the equivalent of fifty Earths'-worth of matter, the neutrinos zip out of the star, carrying away energy and cooling the interior.

Using knowledge of atomic nuclei, we can calculate the energy loss rate and estimate the falling temperature of the star's surface. It is this calculation that led to the conclusion 3C 58 should be significantly hotter than it is.



3C 58'S NEUTRON STAR ISN'T SO HOT. The x-ray brightness of 3C 58's central region (orange curve) matches that expected from non-thermal x rays, those produced by electrons spiraling in an intense magnetic field. An 820-year-old neutron star should generate far more emission at wavelengths longer than 1 nanometer, corresponding to energies less than about 1.25 keV (blue). Even a one-million-kelvin neutron star should create more low-energy photons (green). NASA/SAO/CXC/P. SLANE ET AL.

Way too cool

So what's happening? Several possibilities emerge. If the central density of the star exceeds that of normal atomic nuclei, its protons and neutrons can be squeezed so hard they start to rupture, spilling out their fundamental building blocks — quarks. Six types of quarks are found in nature, with the whimsical names of *up*, *down*, *strange*, *charm*, *top*, and *bottom*. Protons and neutrons are made of triplets of up and down quarks only. But at high enough pressures, the triplets can break, and strange cousins can pop into existence. The particle called lambda, for example, includes one strange quark in its triplet. While physicists have fleetingly produced such peculiar entities in atom smashers, they live at most a tiny fraction of a microsecond under laboratory conditions. But in the core of a neutron star, they could live forever.

Even simple pairs of quarks can form stable particles under these conditions — an up plus an antimatter down makes a pion, and an up paired with an antistrange makes a kaon. Both of these two-quark particles behave very differently from normal nuclear matter — rather than constantly elbowing their neighbors away, they happily settle into a tightly packed crystalline form at the star's center. Should the density go even higher, the nuclei may dissolve completely into a formless sea of quarks. And all of these exotic species boost the neutrino rate enormously, leading to cool young neutron stars like 3C 58.

We found our answer.

Staring at a dead star the size of Manhattan across 10,000 light-years may not seem the best way to study the basics of matter. But the Chandra observations of 3C 58 and a handful of other young neutron stars are giving us looks at matter under conditions never achievable on Earth. At Brookhaven National Laboratory on Long Island, the Relativistic Heavy Ion Collider smashes single gold nuclei into each other to liberate quarks for a fraction of a microsecond. Neutron stars like 3C 58 routinely accomplish this trick on vastly larger and longer scales.

Contrary to what Chinese astrologers thought, guest stars provide no "ill omens." Indeed, throughout modern science, astronomical observations have played a key part in advancing our understanding of the universe. Astronomy is now extending its reach deep into the realms of nuclear and particle physics. Who knows what wonders lie ahead? ■

BY MARTIN RATCLIFFE AND ALISTER LING

MARCH 03

The evening sky provides a great spectacle featuring Jupiter and Saturn — the two largest planets in the solar system — while mornings offer up steadily improving views of Mars.

Winter yields to a planet-rich spring

As darkness descends, the sparkling stars of winter flaunt their brilliance across the southern sky. Bright-white Sirius twinkles closest to the horizon, while golden Capella shines more steadily overhead. The usually prominent Winter Hexagon is pulled out of shape this year by Jupiter's guiding light to the left. The brilliant planet now appears to be at the apex of a huge V-shape pointing east. Alas, to northern observers, the winter stars will succumb quickly to the shorter nights of spring.

A SLENDER CRESCENT MOON bathed in earthshine emerges low in the west after sunset on March 4, then climbs noticeably higher with each passing day. ALAN DYER

The spring, or vernal, equinox arrives on March 20 at 8:00 P.M. EST. At the equinox, day and night are roughly equal in length for the whole planet, not just on the equator.

A slender crescent Moon emerges from the orange twilight into the western sky on the evening of the 4th. Look for the "old Moon in the new Moon's arms" about an hour after sunset. The ashen light comes from reflected earthlight. Exactly at new phase, the Moon lies between Earth and the Sun, and the side of the Moon facing us is without sunlight. However, someone on the Moon would see a full Earth, which would light up the lunar landscape much brighter than a Full Moon does to an earthly winter scene. In the few days after New Moon, the western portion of the Moon is still bathed in earthshine.

Saturn is the modestly bright, steady yellow glow inside the Winter Hexagon. It appears at its best this year: It is the highest it can possibly be for the Northern Hemisphere, and its rings are tipped wide open; next year they begin closing.

By mid-evening, Jupiter commands the sky high in the south. Even the smallest scope will show one or both of its major brownish-purple cloud belts. On the evenings of the 8th, 15th, and 29th, all four Galilean moons lie on one side of Jupiter. A very different scene greets your eye between 2:30 and 4:30 A.M. EST on the 25th: only one moon, Europa, will be visible.

If you're up early or on a coffee break during the night shift, look outside around 5 A.M. Low in the southeast, the orange object you see is Mars. This is a special year for fans of the Red Planet, because on August 27, it will be closer to Earth than at any time in nearly 60,000 years. For more information, turn to "Mars — better than ever" on page 80.

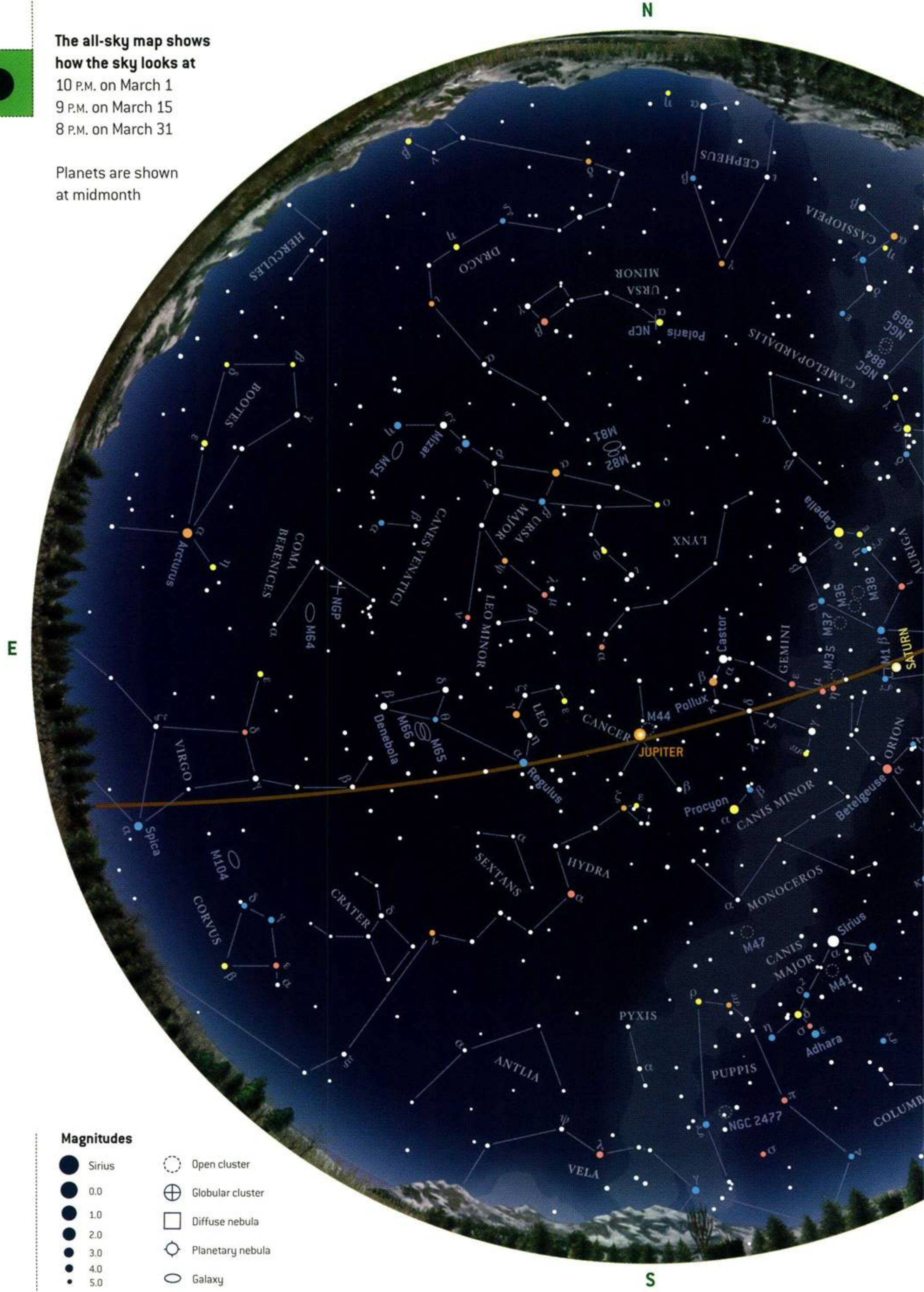
If you've never seen an asteroid before, make Vesta your first. It glows bright enough to track down from the city with binoculars, and there aren't any faint background stars to confuse you.

March is the best time of year to head out to dark skies and attempt a Messier marathon. The 110 Messier objects are the brightest and best star clusters, gas clouds, and galaxies visible from the Northern Hemisphere. While you're at it, check out Comet C/2001 RX14 (LINEAR) riding high above Leo's back.

Are you interested in watching a runaway thermonuclear reaction? With a little luck and patience, you can catch the close binary star U Geminorum brightening by a factor of 100 from one night to the next. It's no coincidence that astronomers call these unusual systems "cataclysmic variables."

The all-sky map shows how the sky looks at
10 P.M. on March 1
9 P.M. on March 15
8 P.M. on March 31

Planets are shown at midmonth

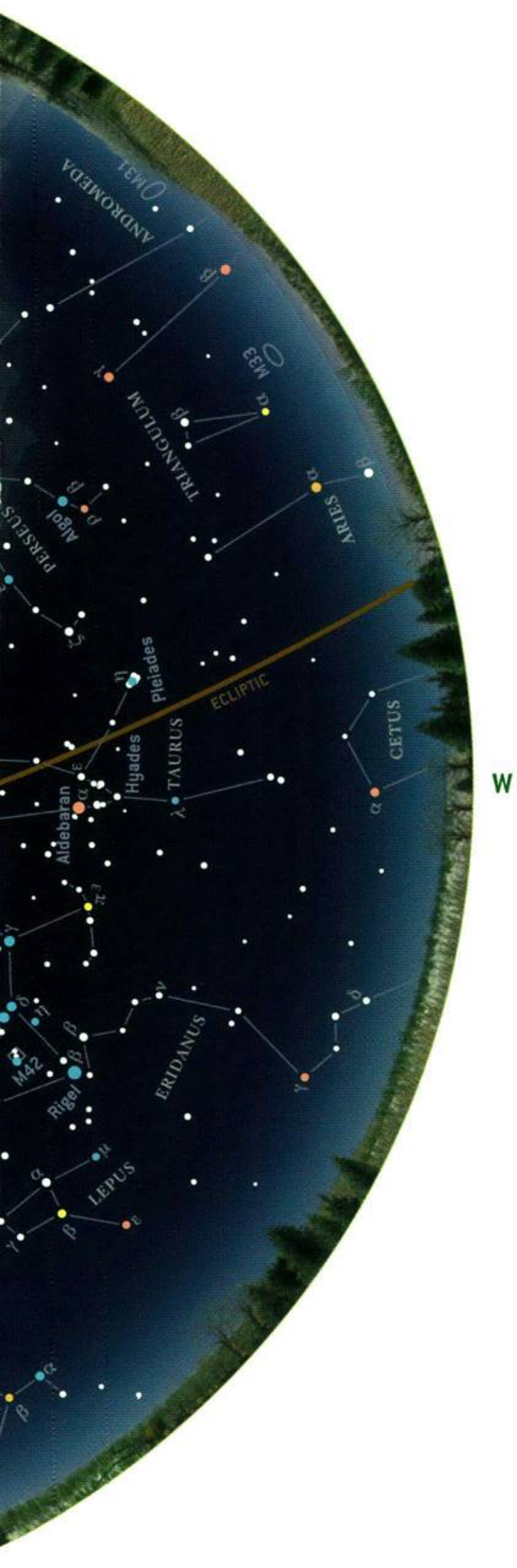

N
E
S
CEPHEUS
CASSIOPEIA
DRACO
URSA MINOR
Polaris
NCP
CAMELOPARDALIS
NGC 869
NGC 884
HERCULES
BOOTES
Arcturus
Mizar
M51
M81
M82
URSA MAJOR
CANES VENATICI
COMA BERENICES
NGP
M64
LEO MINOR
LYNX
Capella
AURIGA
M36
M38
M37
M35
M1
SATURN
GEMINI
Castor
Pollux
CANCER
M44
JUPITER
LEO
Regulus
Denebola
M66
M65
VIRGO
Spica
M104
CORVUS
CRATER
SEXTANS
HYDRA
Procyon
CANIS MINOR
Betelgeuse
ORION
MONOCEROS
M47
Sirius
CANIS MAJOR
M41
Adhara
PYXIS
PUPPIS
NGC 2477
ANTLIA
VELA
COLUMB

Magnitudes

- ● Sirius
- ● 0.0
- ● 1.0
- ● 2.0
- ● 3.0
- ● 4.0
- • 5.0

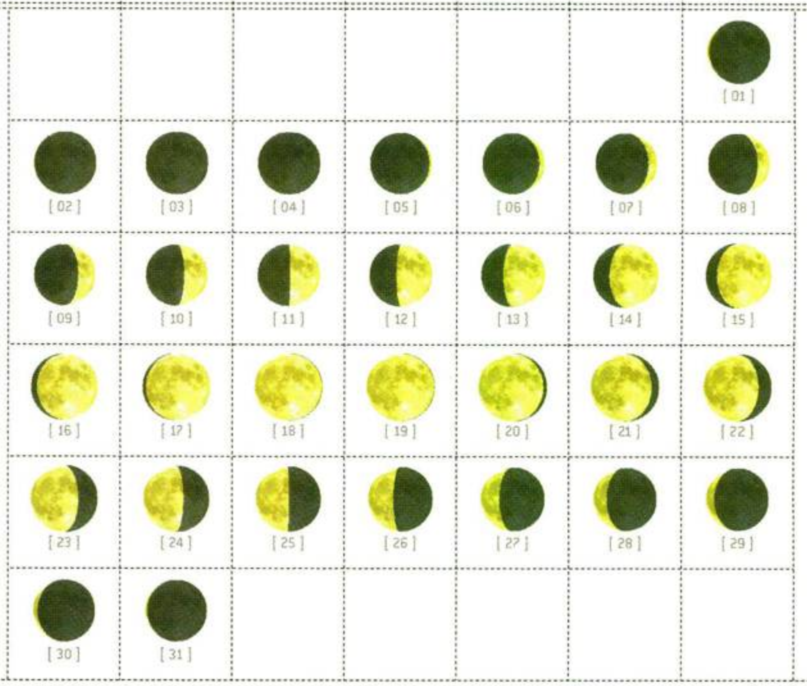
- ◌ Open cluster
- ⊕ Globular cluster
- □ Diffuse nebula
- ⌖ Planetary nebula
- ⬭ Galaxy

This map portrays the sky at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


M31
ANDROMEDA
M33
TRIANGULUM
ARIES
PERSEUS
Algol
Pleiades
ECLIPTIC
Hyades
TAURUS
Aldebaran
CETUS
ERIDANUS
M42
Rigel
LEPUS
W

nd stars above your horizon, hold the map

march 03



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
						[01]
[02]	[03]	[04]	[05]	[06]	[07]	[08]
[09]	[10]	[11]	[12]	[13]	[14]	[15]
[16]	[17]	[18]	[19]	[20]	[21]	[22]
[23]	[24]	[25]	[26]	[27]	[28]	[29]
[30]	[31]					

01 The Moon passes 3° south of Mercury, 10 A.M. EST

02 New Moon is at 9:35 P.M. EST

04 Mercury passes 1.5° south of Uranus, 8 A.M. EST

06 Asteroid Pallas is in conjunction with the Sun, 6 P.M. EST

07 The Moon is at apogee (251,893 miles from Earth), 11:32 A.M. EST

11 First Quarter Moon is at 2:15 A.M. EST
The Moon passes 3° north of Saturn, 7 A.M. EST

12 Venus passes 0.2° north of Neptune, 3 P.M. EST

14 The Moon passes 4° north of Jupiter, 7 P.M. EST

18 Full Moon is at 5:35 A.M. EST

19 The Moon is at perigee (223,580 miles from Earth), 2:01 P.M. EST

20 Vernal equinox is at 8:00 P.M. EST

21 Mercury is in superior conjunction, 7 P.M. EST

24 Last Quarter Moon is at 8:51 P.M. EST

25 The Moon passes 3° south of Mars, 1 P.M. EST

26 Asteroid Vesta is at opposition, 6 P.M. EST

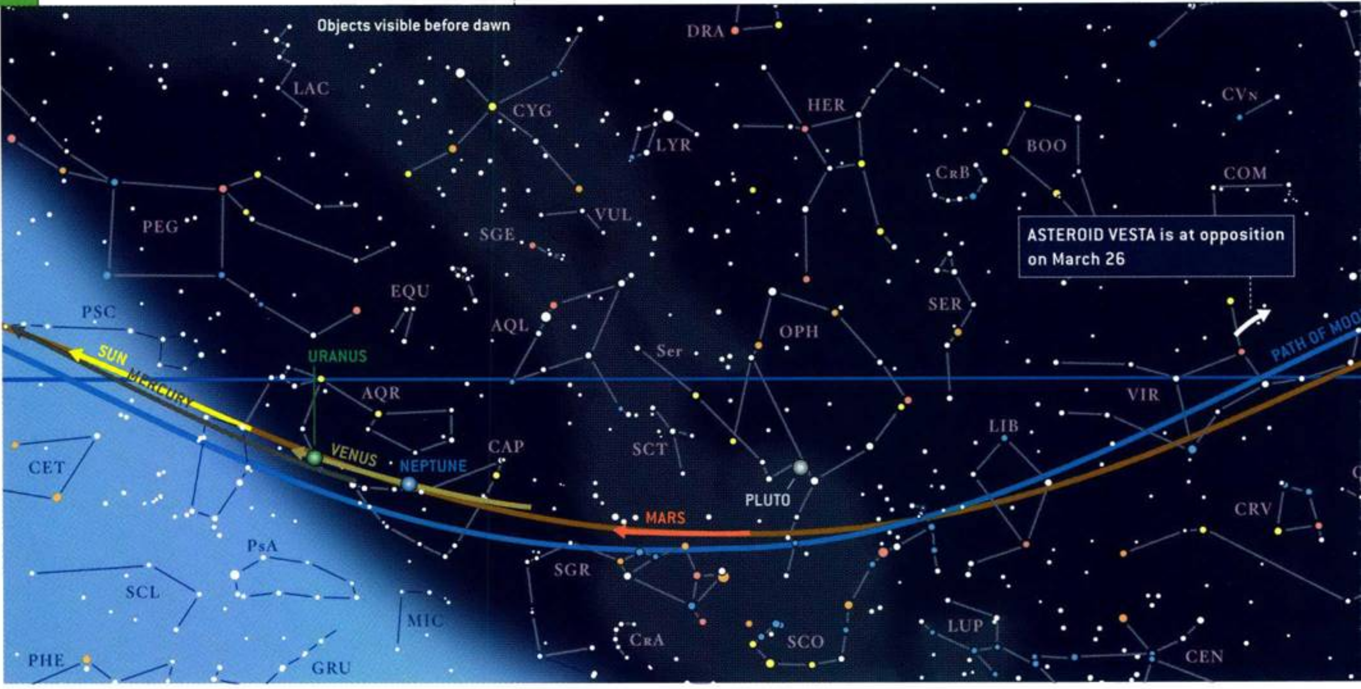
27 The Moon passes 5° south of Neptune, 5 P.M. EST

28 Venus passes 0.05° north of Uranus, 8 A.M. EST

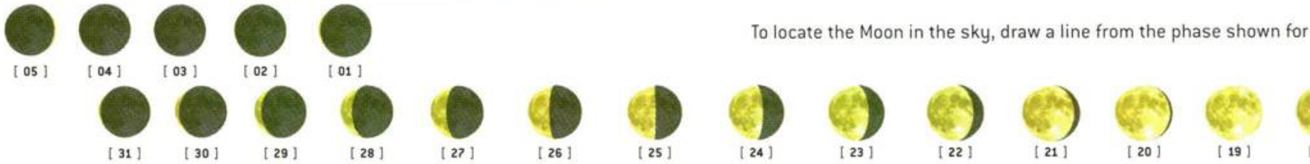
29 The Moon passes 5° south of Uranus, 3 A.M. EST
The Moon passes 5° south of Venus, 5 A.M. EST

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and sq


Objects visible before dawn
DRA
LAC
CYG
HER
CVn
LYR
BOO
COM
PEG
VUL
CrB
SGE
ASTEROID VESTA is at opposition on March 26
EQU
SER
PSC
AQL
OPH
Ser
SUN
MERCURY
URANUS
PATH OF MOO
AQR
VIR
LIB
CET
VENUS
NEPTUNE
CAP
SCT
PLUTO
CRV
MARS
PsA
SGR
SCL
MIC
CrA
SCO
LUP
CEN
PHE
GRU

To locate the Moon in the sky, draw a line from the phase shown for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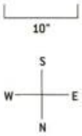
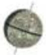
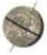
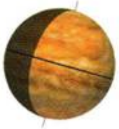
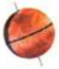
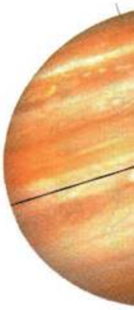
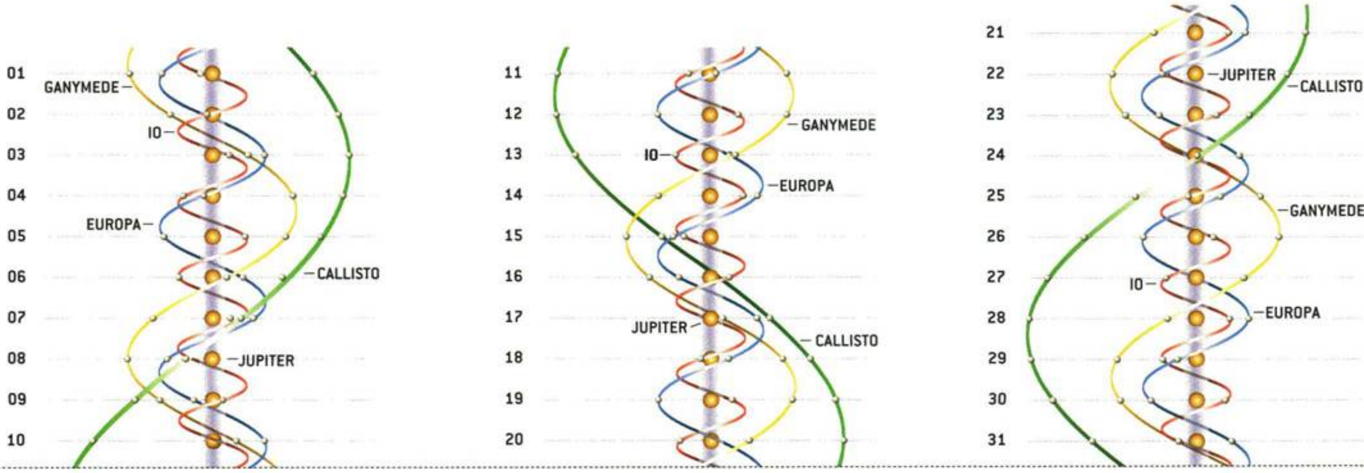


PLANETS	 **MERCURY**	 **MERCURY**	 **VENUS**	 **MARS**
Date	March 1	March 31	March 15	March 15
Magnitude	–0.4	–1.5	–4.0	0.8
Angular Size	5.2"	5.4"	14.7"	6.7"
Illumination	89%	93%	75%	89%
Distance (AU) from Earth	1.301	1.254	1.133	1.400
Distance (AU) from Sun	0.454	0.313	0.726	1.533
Right Ascension (2000.0)	21h45.2m	1h10.5m	21h08.7m	18h27.9m
Declination (2000.0)	–15°40'	7°32'	–16°21'	–23°33'

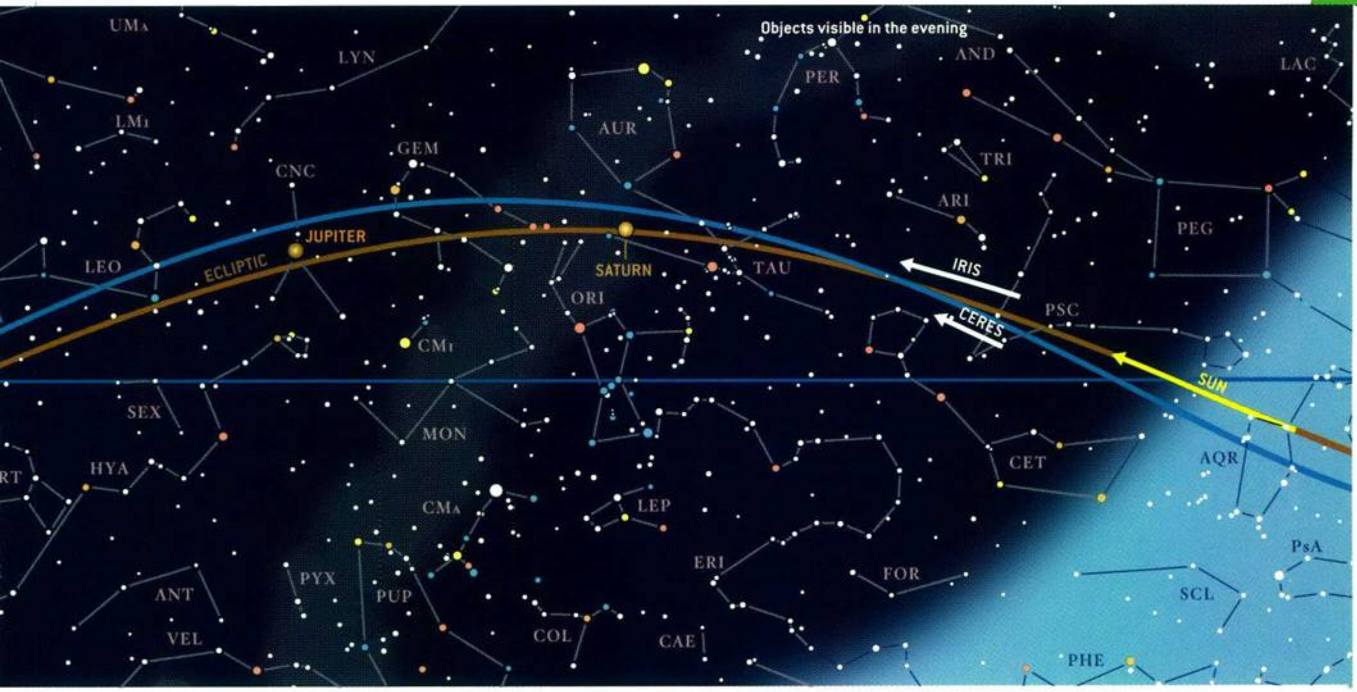


Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope.



uares show motions and locations of solar system objects during the month.


Objects visible in the evening
UMa
LYN
PER
AND
LAC
LMi
AUR
GEM
CNC
TRI
ARI
PEG
JUPITER
ECLIPTIC
LEO
SATURN
TAU
IRIS
ORI
CERES
PSC
CMi
SUN
SEX
MON
CET
AQR
HYA
RT
CMa
LEP
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FOR
ANT
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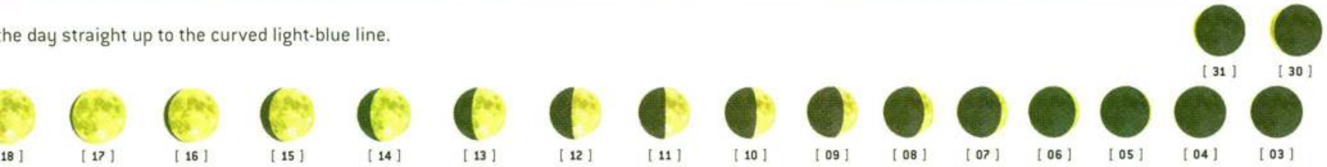
PUP
SCL
VEL
COL
CAE
PHE

he day straight up to the curved light-blue line.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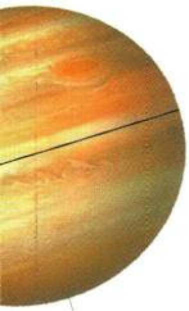
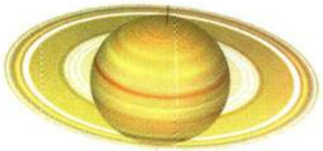
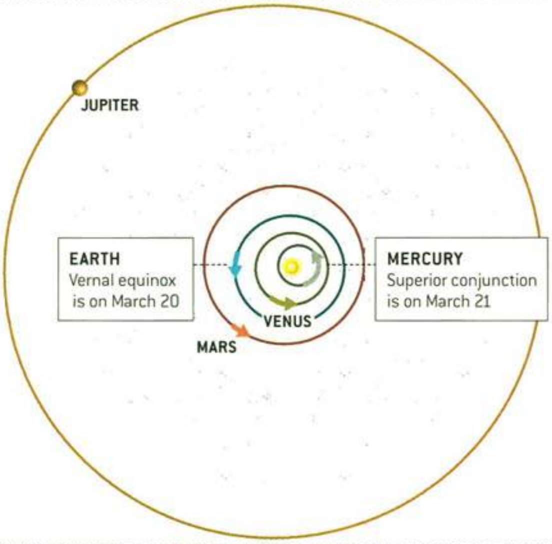


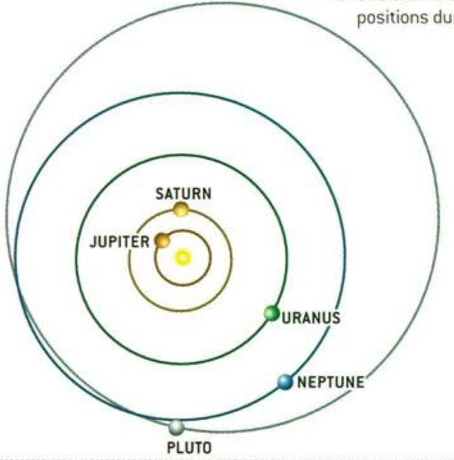


JUPITER	**SATURN**	**URANUS**	**NEPTUNE**	**PLUTO**
March 15	March 15	March 15	March 15	March 15
−2.4	0.0	5.9	8.0	13.9
43.1"	18.5"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
4.579	9.003	20.926	30.817	30.538
5.326	9.033	20.020	30.083	30.623
8h45.3m	5h27.6m	22h10.1m	20h58.4m	17h18.9m
18°57'	22°11'	−12°04'	−17°08'	−13°42'


JUPITER
EARTH
Vernal equinox is on March 20
MERCURY
Superior conjunction is on March 21
VENUS
MARS

The planets in their orbits

Arrows and dots show planets' positions during the month.


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

THE DEEP SKY

Although binary stars are among the most overlooked of deep-sky objects, they have their own subtle charm. This month we highlight a trio of snazzy doubles that will have you begging for more.

Doubles and explosive couples

Stars like to form together, in pairs, associations, and clusters. Thankfully our solar system developed in a loose association; otherwise, we probably wouldn't be here to ponder the starry night. Some pairs orbit leisurely, like Xi Ursae Majoris; others more tightly, like Castor; while some of the most interesting pairs have fiery kisses, like U Geminorum.

Castor might claim the title of best double star in the northern winter sky. The two bright components, shining at magnitudes 2.0 and 2.8, lie a comfortable 4″ apart, twice the minimum separation a 60mm refractor can split at 120x. The pair complete an orbit in about 450 years, and their next close approach takes place sometime around 2435. Interestingly, each of these bright stars is itself a tight pair, detectable only through the study of their spectral lines. Those have orbits of only a few days.

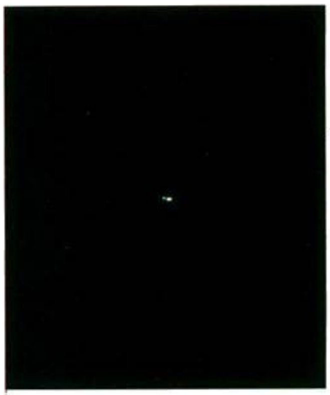
Another exceptional double star is Xi (ξ) Ursae Majoris. You can find Xi using the chart for locating Comet C/2001 RX14 (LINEAR) on page 69. It was the first binary to have its orbit computed, which gave a period of about 60 years. Sir William Herschel, the undisputed father of deep-sky observing, set out to prove that the Xi pair were unrelated, passing each other in straight lines. After a few years of careful observation, he had no doubt that they must be orbiting each other, providing more proof that Newton's law of gravity is indeed universal.

We see the pair from the top down, so the two never get too close. Currently the 4.3- and 4.8-magnitude couple lie 1.8″ apart, a challenge for a 60mm refractor.

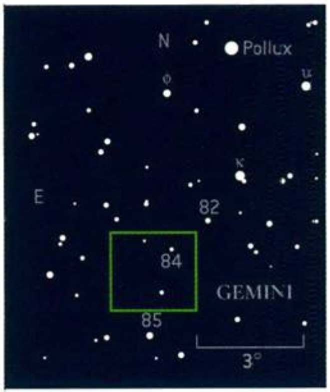
When's the "kaboom"?

A swollen red star dumps fuel toward its hot blue companion. Caught in a swirling spiral, the gas builds up in a disk around the hot star until it can't take anymore. Thermonuclear ignition kick-starts a runaway reaction that puts out 100 times more light than the system did a day before.

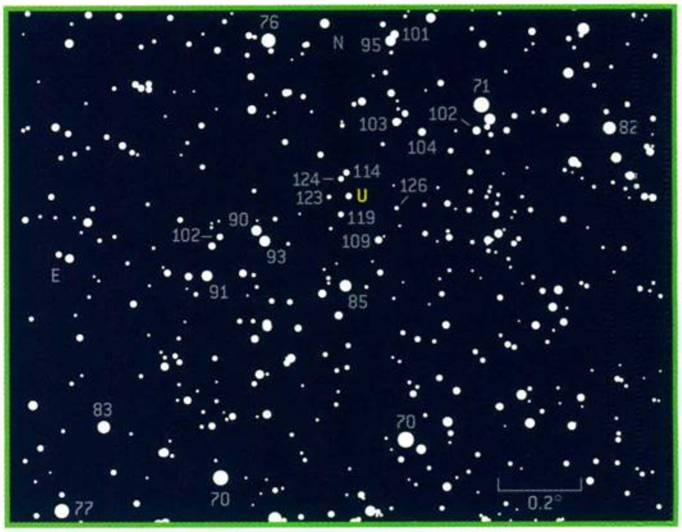
This is the story of U Geminorum, a 14th-magnitude fleck that bursts onto the scene at 9th magnitude every 100 days or so. Through a telescope, you may see nothing at first. But keep at it and you will suddenly find a sparkling gem in the right place. If you're lucky, you'll see it at 12th magnitude and watch it brighten during the course of the night.



ONE OF THE FINEST DOUBLES in the northern winter sky, Gemini's Castor can be split easily in a small telescope. BRIAN SKIFF



U GEM LIES SOUTH of Pollux (above). Use the comparison chart (below) to determine its magnitude. ALL ILLUSTRATIONS BY ROEN KELLY



The first time you locate the field of U Gem, it may take 20 or 30 minutes to find. Each following night you can probably cut five minutes off the search time until you're down to one minute. Then it's just a matter of time before you get a jolt of joy from the fury of fusion.

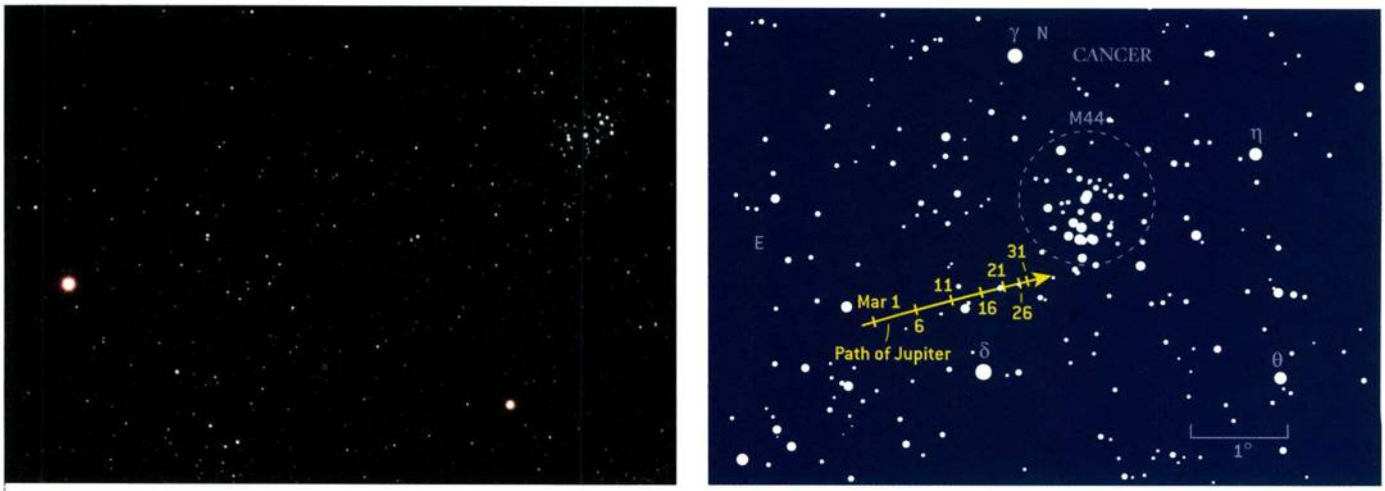
U Gem is but a short hop south of Castor and Pollux. Once you've found the region, use the detailed comparison chart above to estimate the star's magnitude (decimal points have been omitted from the map to avoid confusion with stars).

Astronomers can't predict U Gem's eruptions with any accuracy, other than it takes at least 60 nights between bursts. Sometimes patience does have its rewards.

Martin Ratcliffe *is President of the International Planetarium Society.* **Alister Ling** *is a meteorologist with Environment Canada.*

THE PLANETS

The three outer members of our planetary system take a well-deserved break during March, but the ongoing antics of Venus, Mars, Jupiter, and Saturn will bring a smile to the face of any planetary observer.



JUPITER AND SATURN added to the luster of Taurus in 2000 (left — bright Jupiter appeared north of Aldebaran and Saturn south of the Pleiades). JIM BAUMGARDT Although they have since separated significantly, they remain fixtures in March's evening sky, with Jupiter approaching the star cluster M44 (right).

The two major planets in our solar system, Jupiter and Saturn, continue their domination of the evening sky. As springtime approaches, the Sun appears to persist above the western horizon longer each late afternoon, reducing the number of hours that the planets are visible. The sky darkens around 7 P.M. local time on March 1, but the Sun sets more than half an hour later on the 31st.

Once the sky grows dark, both planets stand high in the sky, providing good conditions for telescope views. When a planet is high, its light passes through less of our atmosphere, minimizing the odds that air turbulence will distort the image.

Jupiter easily wins a brightness competition, shining at magnitude –2.4, while 0.0-magnitude Saturn appears dimmer and lies farther west.

Look for **Saturn** standing between the horns of Taurus the Bull, near the location of the Crab Nebula (M1). On March 1, the Ringed Planet stands less than 3° from Zeta (ζ) Tauri. Its eastward motion against the background stars slowly increases this month, although the effect is hardly noticeable because Earth is moving almost directly away from Saturn. The planet's apparent diameter shrinks by 1″ during March, ending the month at 18″ across.

Saturn reveals the splendor of its 42″-diameter ring system in any telescope. The rings' southern face now tilts at a maximum to our line of sight. Subsequent years will see the rings gradually close, until they lie edge-on in 2009.

The Cassini Division, a narrow gap between rings A and B, was discovered in 1675 by Giovanni Cassini and can be seen in most telescopes. The same name adorns the Cassini spacecraft, which is now closing in on Saturn. This international mission includes NASA's giant orbiter plus a European probe, Huygens, destined for the atmosphere of Saturn's largest moon, Titan. The Cassini spacecraft will reach the Ringed Planet in mid-2004. The multi-year orbiting mission will provide an unprecedented, continuous view of Saturn from close quarters.

Cassini will also transform our view of Saturn's satellites, making dozens of close passes by each of the major moons. A thick, hazy atmosphere envelops Titan, keeping the planet-sized moon mysterious — at least until Huygens arrives. You can see Titan through any small telescope, orbiting Saturn every 16 days. Titan spends the first and third weeks of March lying on the western side of Saturn and the intervening weeks to the east of the planet. It passes due north of Saturn on March 16 and due south on March 7 and 23.

Telescopes bigger than 6 inches (150mm) can easily show Iapetus. This most unusual moon appears brightest on the western side of Saturn, when its brighter hemisphere faces us. This occurred in mid-February, and Iapetus then shone at magnitude 10.1. As Iapetus moves to the east of Saturn it dims to magnitude 11.9. It reaches eastern elongation on March 26. Our own Moon stands about 4° northwest of Saturn on March 10/11.

Jupiter is the first planet to peek out of the bright evening sky following sunset. As twilight deepens, look for the brilliant planet high in the southeast. The best way to begin observing Jupiter is with binoculars. Once the sky is truly dark, grab a pair and view the planet. Lying within the same field of view is one of the finest open star clusters, M44, also known as the Beehive Cluster (or Praesepe). With visiting Jupiter, the scene is stunning. Jupiter outshines the stars in the Beehive only because the planet lies so close to us. In reality, each star outshines Jupiter billions of times, but their sheer remoteness results in a relatively feeble glow. For the same reason, our Moon outshines Jupiter. You can see this for yourself on March 14, when the Moon stands 4° north of the planet.

Jupiter reached opposition in February and so still appears large in a telescope. Its apparent size shrinks by 7 percent during March; by the 31st, it spans 41″ across the equator. The best time to view Jupiter is when it stands high in the sky, so check out its features shortly after sunset. The jovian atmosphere invariably shows lots of activity. The two most evident features are the North and South Equatorial Belts — two parallel dark belts that cross the equatorial span. When trying to identify each one, remember that astronomical telescopes usually invert the image, putting south at the top.

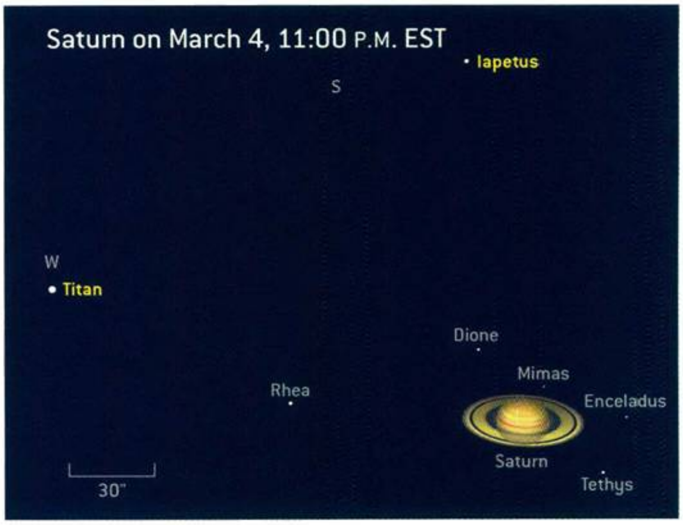
Jupiter's four bright Galilean moons — Io, Europa, Ganymede, and Callisto — are an easy catch for any telescope and even for larger tripod-mounted binoculars. The relative positions of the satellites change hourly, and nightly. Occasionally, one moon may eclipse or occult another, a phenomenon known as a mutual event. Such events occur at six-year intervals, when our line of sight lies in the same plane as the orbits of Jupiter's moons. Of the 42 events during March, about 40 percent are visible from at least part of the United States and Canada. (See "Shadow Play around Jupiter," December 2002, for complete details on the mutual events.) Here are a few March highlights.

On the American evening of February 28 (March 1 in Europe), the disk of Europa occults Callisto at 9:59 P.M. EST (2:59 Universal Time) for nearly 8 minutes. One hour later the shadow of Io eclipses Callisto at 10:56 P.M. EST (3:56 UT), lasting for two minutes.

Io and Europa join forces on the American night of March 2/3. Io first occults Europa at 1:47 A.M. EST, then, one hour later at 2:46 A.M. EST, Europa is eclipsed by Io's shadow.

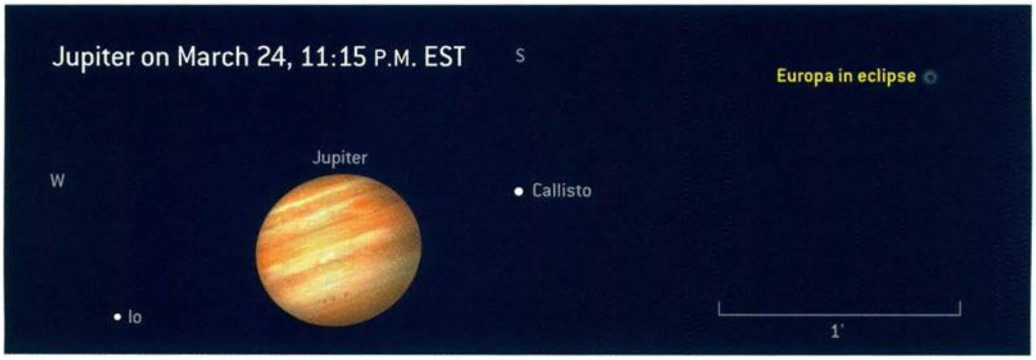
On March 8, Callisto occults Io at 11:09 P.M. EST (4:09 UT on the 9th). Three hours and 13 minutes later, Io passes into Callisto's shadow.

Perhaps the best mutual event of the month occurs on the American evening of March 24 (March 25 in Europe), when Europa passes into Callisto's shadow. The eclipse begins at 11:13 P.M. EST (4:13 UT on the 25th) and lasts just 3 minutes and 33 seconds. At maximum eclipse, Europa's brightness dims by 82 percent.



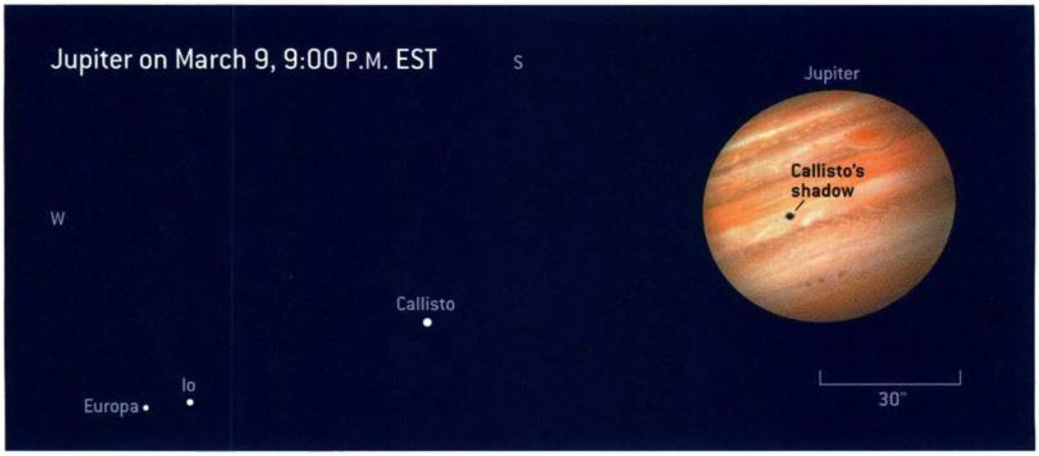
Mars clears the southeastern horizon by 3 A.M. local time in early March, about an hour after its ancient rival, the star Antares. Although it glows quite brightly at magnitude 0.8 this month, it remains too small to see any appreciable details on its ruddy surface. That will begin to change by the end of April, and this summer Mars will be at its best in millennia. Don't miss the fine binocular sight of Mars passing between the Lagoon and Trifid nebulae (M8 and M20) in the predawn hours of March 5 and 6. On March 17 and 18, Mars lies in the same low-power telescopic field of view as the bright globular cluster M22, just a few degrees northeast of Lambda (λ) Sagittarii.

The brilliant orb of **Venus** pokes above the eastern horizon before dawn, but remains visible only briefly. It becomes harder to view as its elongation from the Sun shrinks. A telescope shows its –4.0-magnitude disk, which appears 15″ across and 75 percent illuminated in mid-March.



METEORS AND MOONS

A spectacular trio of lunar craters greets observers shortly before First Quarter Moon, while the darkest, most heavily cratered Galilean satellite continues to pass in front of and behind Jupiter.

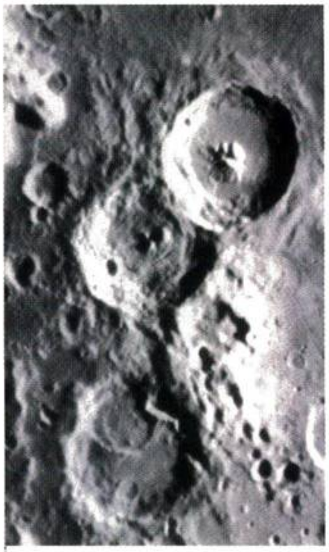

Jupiter on March 9, 9:00 P.M. EST

There are no significant meteor showers this month, and the sporadic rate is very low. However, it's worth keeping an eye out for the occasional fireball.

Theophilus, Cyrillus, and Catharina

Theophilus is one of the most striking, dramatic craters on the Moon. It sits in the southeast quadrant of the Moon, west of Mare Nectaris, and is flanked to the south and west by the fine scarp called Rupes Altai. Two other large craters lie south of Theophilus: Cyrillus and Catharina. The trio provides a dramatic interplay of shadows and highlights as the Sun rises over the features five to six days after New Moon.

Take note of the differences among the three craters. The 60-mile-wide (100-km) Theophilus is youngest. It sports fine terraces, reminiscent of Copernicus, and its multiple central mountain peaks stand clear of a smooth floor. The Theophilus impact clearly occurred after the one that formed Cyrillus, whose walls appear more degraded, indicating a greater age. Catharina, the southernmost of the chain, shows no central peak and rough crater walls, confirming it as the oldest of the three. Under certain illuminations, the floors of each crater can be seen to lie at different levels, providing further clues to the violent events that formed these craters. The Sun sets on this area about 15 days after rising over the rugged terrain. Observe from March 8 through March 23 to see the full interplay of light across this dramatic region.


MULTIPLE CENTRAL PEAKS highlight Theophilus, the northernmost of three prominent lunar craters on the western shore of Mare Nectaris. Heading south, Cyrillus and then Catharina are older and appear more degraded. LEO AERTS

Jupiter's satellites

The rare occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue throughout the month. During each 12-year orbit of Jupiter around the Sun, only two series of these Callisto events occur. The current one began in late 2001 and will continue until September 2004. Only 66 eclipses will take place during this time frame. The events listed in the table at right are given in 24-hour format in both Universal and Eastern Standard Time. Those that occur on either side of midnight are shown twice because the date changes for observers depending on whether they live in Europe or North America. Tr = transit; I = Ingress; E = Egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance.

/// MARCH CALLISTO EVENTS

	{ UT }	{ EST }	{ Event }
8TH	15:45	10:45	IV.Tr.I.
	20:30	15:30	IV.Tr.E.
	23:06	18:06	IV.Sh.I.
		22:53	IV.Sh.E.*
9TH	3:53		IV.Sh.E.*
16TH	21:59	16:59	IV.Oc.D.
		21:51	IV.Oc.R.*
17TH	2:51		IV.Oc.R.*
	6:54	1:54	IV.Ec.D.
	11:47	6:47	IV.Ec.R.
25TH	7:17	2:17	IV.Tr.I.
	12:03	7:03	IV.Tr.E.
	17:07	12:07	IV.Sh.I.
	21:54	16:54	IV.Sh.E.

*Events that occur on either side of midnight are shown twice.

The events are worth viewing due to their relative rarity. Not all events can be seen from the United States.

COMETS AND ASTEROIDS

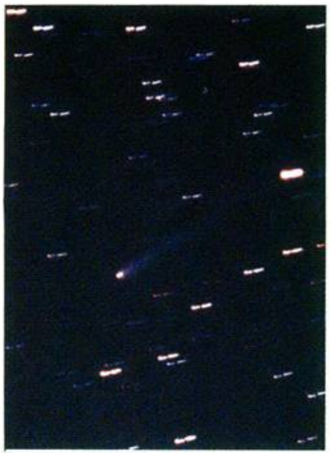
Comet C/2001 RX14 [LINEAR] fades to 10th magnitude as it plies the backwaters of southern Ursa Major, but the brightest of the solar system's minor bodies, the asteroid Vesta, reaches naked-eye visibility.

A LINEAR treat

It's already been a year since Comet Ikeya-Zhang paid us a surprise visit. And in only 14 months, Comet C/2001 Q4 (NEAT) is expected to swing by and glow brightly at 1st magnitude. Until then we must content ourselves with slower and fainter comets, such as C/2001 RX14 (LINEAR).

Rising in the northeast during the evening hours, RX14 (LINEAR) is expected to shine at about 10th magnitude, making it just a bit tougher to locate than the faint end of the Messier list. This means that a 4-inch scope under dark moonless skies is all you'll need to detect this interloper.

Despite its location in Ursa Major, RX14 (LINEAR) is probably easier to get to if you jump north off of Leo's back to Xi (ξ) and Nu (ν) UMa. Pump up the power on Xi to find its true nature — a double star, which we feature on page 65. From there, use the detailed chart at right to hop to the fuzzy snowball.



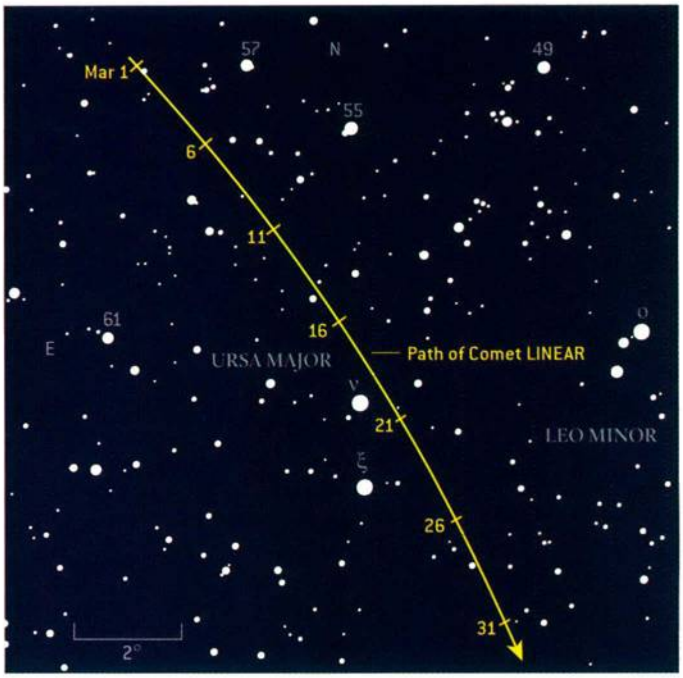
COMET C/2001 RX14 [LINEAR] fades slightly this month but remains within the reach of backyard telescopes among the stars of Ursa Major. MICHAEL JÄGER

There's a chance you may not at first see this low-surface-brightness object at low power. It's time to pull out the deep-sky observer's bag of tricks. Use a dark cloth to cover your head and eyepiece to block out all extraneous light sources. Then slowly nudge the scope a bit. Your peripheral vision is surprisingly sensitive to motion. I've also noticed that many amateurs use bright red lights. Even though it is red, a bright source will still hurt your night vision. Dim it as much as possible and cover your observing eye while reading the chart. Finally, bump up the power to 100x or so, because big faint objects are easier to detect than small faint objects.

If you're staying up all night doing a Messier marathon, challenge yourself with a search for periodic comet Wild 4. At 12th magnitude, it won't be easy to locate, floating near the faint globular cluster NGC 5897 in Libra.

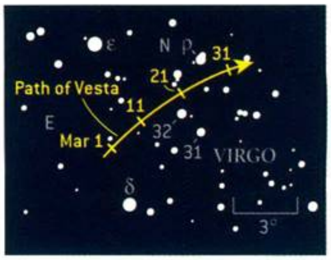
Seeing an asteroid with binoculars

If you're city-bound like most observers, it's a treat to follow an easy target. Vesta shines brightly this month, peaking at magnitude 5.9, meaning you could do the nearly unthinkable: Step out into your light-polluted backyard without dark-adapting, point your binoculars at the right spot, and see it. If you want to challenge your hawkish eyes, try to find it with unaided eyes from a dark site.



The fourth asteroid to be discovered, on March 29, 1807, Vesta is a bright rock. Compared with our Moon, which reflects only 6 percent of the light that hits it, Vesta's reflectivity is a whopping 38 percent, much shinier than most asteroids.

To find Vesta, you'll have to wait until mid-evening, when it has climbed comfortably above the horizon but not so high as to strain your neck. Locate the two stars in Virgo that frame it, Delta (δ) and Epsilon (ε) Virginis, aim about halfway between the two, and the first thing you'll see is the asteroid.



Can't wait for it to rise? Swing a scope toward Aries and jump over to 15 Eunomia. At 10th magnitude, this asteroid requires a 6-inch scope from an average big-city backyard. On the 11th it passes near the spectacular double star Gamma (γ) Arietis.

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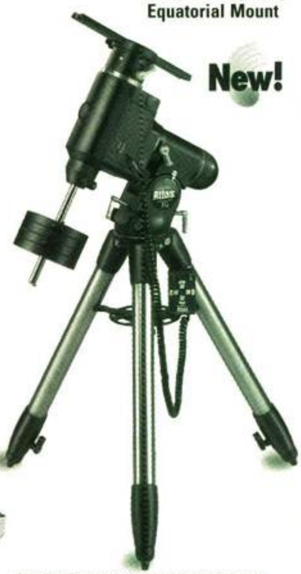

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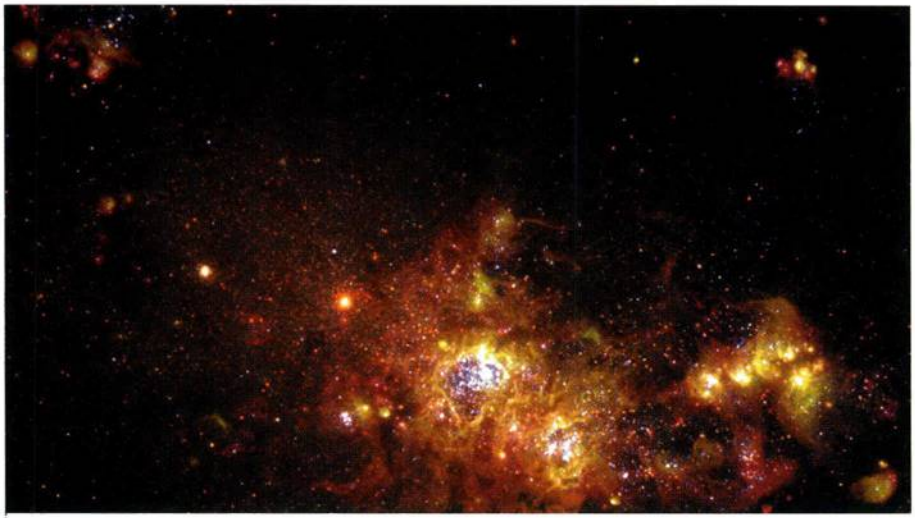
SOLAR SYSTEM

Where do astronomers think the Sun formed? Is it possible any nearby nebulae could be the source?

— **ERIK DEWITT,** EAST HAVEN, CONNECTICUT



DISTORTED GALAXY NGC 4214 reveals the fireworks of star formation. Stars and star clusters are evolving in this galaxy much like our Sun did more than 4.5 billion years ago. NASA, THE HUBBLE HERITAGE TEAM

Planetary scientists know when the Sun formed, but not where. The "when" comes from studies of meteorites, the oldest and least-changed rocks in the solar system. By carefully measuring the amount of naturally occurring radioactivity left in meteorites, scientists have come up with a firm number of 4.56 billion years for the age of the solar system. This is also the age of the Sun since it formed at the same time that its planetary family did and from the same nebular cloud of dusty gas.

Unfortunately, the "where" is an unsolvable problem; too much time has passed. From where we now sit in the Milky Way — two-thirds of the way out from the center, on the edge of a spiral arm — the Sun follows an orbit around the galactic core that takes about 200 million years. Such is one "galactic year." Simple arithmetic therefore tells us that the Sun has gone around the galaxy many, many times since its formation.

When we search for the Sun's birth-parents, we confront the fact that the stars and nebulae lying close to the Sun when it formed no longer live around here. They have all moved on. Those that lie nearby at present share in the general rotation of the galaxy with the Sun — for now. But each has its own random velocity that causes it to drift relative to the others. Over time, today's galactic neighbors, too, will move away.

And that's not even counting intrinsic changes. The population of our galactic neighborhood alters greatly in only a few million years. Stars much hotter than the Sun, for example, burn out within a galactic rotation or less. Also, nebulae that give birth to stars don't last long. Once stars have formed from the gas and dust, the stars' light (especially ultraviolet radiation from the most massive stars) heats the gas and disperses it, and radiation pressure drives the dust away. Astronomers can see this happening now in star-forming regions in Taurus and especially Orion.

The entire cycle of star formation and nebular dispersal takes only a few million years, so the nebula in which our Sun formed is long gone.

— **STUART WEIDENSCHILLING,** PLANETARY SCIENCE INSTITUTE, TUCSON, ARIZONA

CHANGING SEASONS

Why do we have four seasons on Earth? Is there an astronomical or historical explanation? How many seasons does Mars have? What about other planets?

— **GORAN VLAHOVIC,** ZAGREB, CROATIA

Earth has four seasons because its yearly orbit has four astronomically determined points that affect climate. These are the two dates when Earth's polar axis, which tilts about 23° to its orbit, points most directly toward and away from the Sun (the summer and winter solstices) and the two times when the Sun lies directly above Earth's equator (the spring and fall equinoxes). The dates fall in June and December (the solstices) and March and September (the equinoxes).

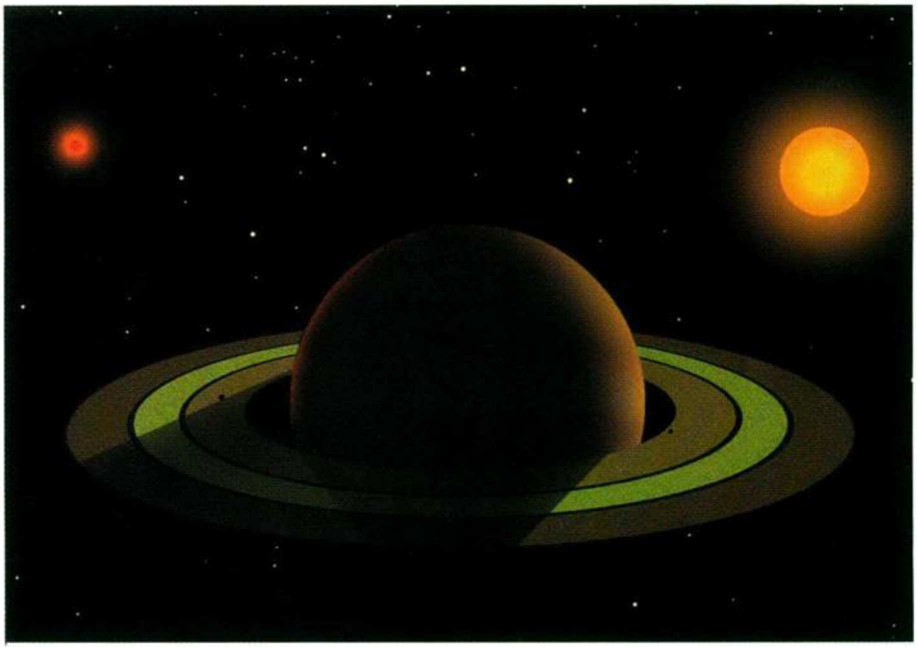
Although astronomy gives Earth four distinct seasons, in many locations geography and climate simplify the year to just two: a wet season and a dry one. Other places effectively experience only three seasons. (And some go the opposite way: in parts of the world people insist there's a "mud season" between winter and spring!) In any case, every planet whose axis stands at an angle to its orbit around the Sun will experience four seasons, at least astronomically.

You might think that a planet's axis could take any random tilt. But in fact the axial tilts of the planets (called the obliquity) fall into distinct groups. One group has obliquities less than 7° while another clusters around 25°. The first group includes Mercury (0°), Venus (3°), the Moon (7°), and Jupiter (3°). The second has Earth (23°), Mars (25°), Saturn (27°), and Neptune (28°). Neither Uranus (82°) nor Pluto (57°) fit the scheme — but what's a rule without an exception or two? And Pluto, at least, doesn't fit among either the terrestrial planets or the gas giants.

With Venus, reference books commonly say its axis tilts at 177°, but this is just to indicate that it rotates in a direction opposite that of most planets. As far as astronomical seasons are concerned, its axis stands nearly at right angles to its orbit.

The effects of seasonal change vary greatly among the planets. Among the zero-tilt group, these effects are nil or close to it among the zero-tilt group. In the middle group, Earth's changes are well known, and those of Mars are becoming better understood thanks to spacecraft exploration. Saturn has some seasonal effects, but its massive atmosphere and the slow pace of change due to its 30-year orbit make study difficult. (The Cassini spacecraft, due to arrive at Saturn in July 2004, will certainly help, although even an extended mission for Cassini won't last more than part of one saturnian year.)

Observations of the other planets suggest that Neptune and Uranus both display seasonal changes, but their lengthy years and great distances from Earth make the picture murky. The same holds even more strongly for Pluto. This dim, small, remote world sees its atmosphere come and go during the year, freezing out as frost in winter. But this occurs mostly due to the changes in sunlight it receives, which vary annually almost three-fold, than by the seasonal effects of its extreme axial tilt. — **ROBERT BURNHAM,** CONTRIBUTING EDITOR



BINARY STAR GAMMA CEPHEI harbors a recently discovered planet that orbits the bright yellow primary once every 2.5 years. The system's reddish secondary glows feebly in the background. TIM JONES/MCDONALD OBSERVATORY

EXTRASOLAR PLANETS

What would the orbit of a planet around a binary star system look like? Would it be possible for the planet to have a stable orbit in a figure-eight around both stars?

— **THOMAS M. EARNHART,**
JACKSONVILLE, FLORIDA

Planets can orbit within double-star (binary) systems, but only if they behave themselves. There are just two possible cases: Either one star acts on the planet to the exclusion of the other — or the two stars act on the planet as if they were single.

In the first case, the stars must be very widely separated. The planet then orbits one of the stars much as our planets orbit our Sun. The second star is so distant that it has little gravitational effect on the first star's planetary system.

Such systems exist. In the double-star system called 16 Cygni, a Jupiter-like planet orbits the fainter of the two, 16 Cygni B. The brighter star, 16 Cygni A, lies at least 840 astronomical units away from 16 Cygni B, over 20 times Pluto's distance from the Sun. B's planet happily orbits with A, appearing as a brilliant star comparable to our Full Moon. (How wonderful to live in such a system, with another star nearby to explore!)

In the second case, the binary's stars lie so close together that they act as a single gravitational source with the planet much farther out. No such systems have yet been found. The problem parallels that of triple and multiple stars. In stable systems, a third star (or another close double) orbits a tightly-bound pair. However, if the stars lie at roughly the same distances from each other, as in Orion's Trapezium, one or more will eventually be ejected.

A planet strongly affected by two or more stars would suffer the same fate. Therefore, transferring a planet from one star to another in a figure-eight orbit would be impossible. In fact, since planets grow from dusty disks orbiting new stars, even the formation of such an unstable planet would be prohibited, since one star would rip up the other's disk. — **JIM KALER,** ASTRONOMY DEPARTMENT, UNIVERSITY OF ILLINOIS.

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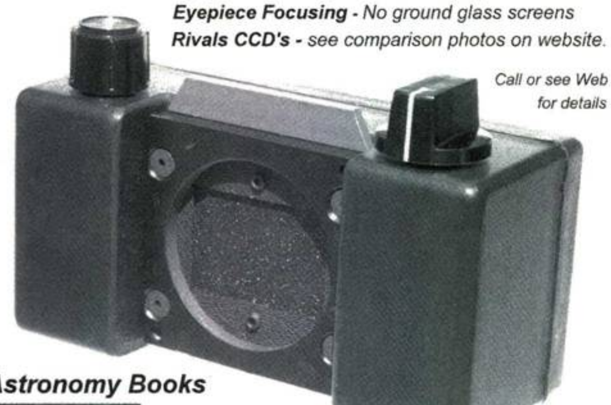

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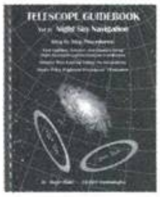

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Corvus, Crater, and Sextans

Easily overlooked, these three simple constellations hold a treasure-trove of exotic galaxies. /// BY TOM POLAKIS

Don't let the dim stars of Corvus, Crater, and Sextans fool you. Sandwiched between the giants Hydra and Virgo, these unimposing constellations may not seem like much at first, but take a closer look. The trio acts as a window on distant galaxies and makes a rich target for early spring observing. ☾ Sextans the Sextant holds only one star brighter than 5th magnitude and a dozen brighter than 6th magnitude. It's a challenge for observers to make out the constellation's brightest stars, which are drawn either as a three- or four-star grouping. The four brightest stars of Sextans are all rather ordinary white suns several hundred light-years away.

To the southeast, Crater the Cup somewhat lives up to its name. A chain of six stars of magnitude 4 and 5 form the shape of a "U" on its side. The brightest of these is Delta (δ) Crateris, whose spectral type (K) is evidenced by a yellow tint. To the southwest, the slightly fainter Alpha (α) Crateris shows a similar hue.

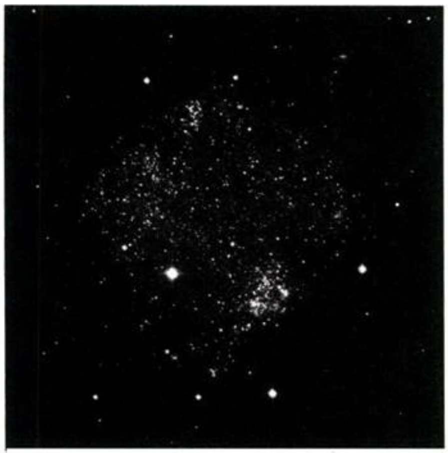
Continuing to the east, the pronounced form of Corvus the Crow comes into view. Four 3rd-magnitude stars form a nearly square figure that stands out well in an otherwise star-poor field. Alpha Corvi is just south of Epsilon (ε) Corvi. Epsilon is six times farther away but a hundred times as luminous as its neighbor.

As usual, our tour runs from west to east, beginning at a beautiful edge-on galaxy in Sextans. **NGC 3044** lies at the apex of a flattened triangle with Alpha Sextantis and Iota (ι) Hydrae. In a telescope of modest aperture, it is 4′ long and only 1′ wide, elongated in position angle (p.a.) 120°. The entire spindle is faint but brightens very slightly in the middle. NGC 3044 is an isolated galaxy 50 million light-years away with very few signs of past interactions. Long-exposure photographs show slight asymmetry on the northwest end.

Sextans is home to several nearby dwarf galaxies. Lying only 4.5 million light-years away but still just outside the bounds of the Local Group is **Sextans B**. A 13-inch telescope at a dark site turns up a cometary haze about 2′ by 1′. Smaller apertures show only the broadly concentrated core, which is half this size. If you are using a light bucket, be sure to apply magnifications of at least 250x and look for a curdled appearance, the first sign of resolved stars. Individual stars will be very difficult to make out, however, as the brightest are only magnitude 19.

Four degrees to the east-southeast is a close pair of galaxies that show up attractively in modest telescopes. **NGC 3169** is only 8′ away from the similarly bright galaxy NGC 3166. The pair form a non-interacting quartet with NGC 3165 and NGC 3156, all 50 million light-years away. Telescopically, NGC 3169 is quite bright, 1.5′ wide and about twice as long, and displays a much brighter nucleus. NGC 3166 appears in images as a spiral galaxy that is elongated 2:1, but visually it looks more like a circular haze 2′ across with a stellar core. The faint extensions to the east and west are visible only with a large telescope at a dark site.

NGC 3115, the Spindle Galaxy, is certainly the showpiece of Sextans. It is the prototype of S0 galaxies, a class that was introduced by Edwin Hubble to bridge the gap between the longest ellipticals and spirals. They are typically dominated by a bulge and long extensions, but they have no spiral arms. Studies show the disk's rotational velocity declines with distance from the galaxy's nucleus, which supports the notion of a large, central black hole. It's surprising that Messier missed a galaxy as bright as NGC 3115, which is 35 million light-years away, as it shows up well in today's finder scopes. In a small scope, the Spindle is 4′ by 1′ around a very bright center. In a 12-inch, the length extends to 6′, and a fainter oval



SEXTANS A is a squarish dwarf galaxy with a bright HII region at its southeast edge (lower right in this view). MOUNT WILSON AND PALOMAR OBSERVATORIES

bulge surrounds the center. The largest scopes show a dwarf elliptical companion, NGC 3115 DW1, 17′ to the southeast.

The second of the dwarf galaxies on our list, **Sextans A**, was also recently disqualified as a Local Group member despite being only 5 million light-years away. This odd-looking dwarf irregular appears on long-exposure images as a square group of faint, resolved stars seen nearly face-on. A telescope with at least 8 inches of aperture is probably required to show the light of this galaxy. The brightest feature is an HII region at the southeast edge that might be worth a shot with a nebula filter.

The Sextans Dwarf rounds out the list of dwarf galaxies. It was discovered in 1991 as an increase in star density on photographic plates. Despite its proximity — only 280,000 light-years away — it is nearly impossible to observe and remains the least-studied galaxy associated with the Milky Way.

Less than 1° northwest of Alpha Sextantis lies the one globular cluster in this month's selection. **Palomar 3** is a distant cluster that shows up on photographs as a clump of faint stars a few arcminutes across. Viewing with a 17-inch telescope, Texas observer Barbara Wilson was able to see the tiny globular at high magnification as a dim haze.

In Crater, move the scope 2° west of Beta (β) Crateris to find a bright spiral galaxy seen nearly edge-on. Elongated east-west, **NGC 3511** spans 4′ by 1′. The texture of the galaxy is mottled, leading inward to a bright, oval core that appears to be offset to the north of center. A 13th-magnitude star lies in front of the east end of the galaxy. Only 11′ southeast in the same telescopic field you can find the small barred spiral galaxy **NGC 3513**. It initially presents a featureless, circular haze 2′ across with a brighter middle. A more careful look reveals the thin central bar with its long axis oriented east-west.

Pan 1° north of Epsilon Crateris to sweep up the moderately bright spiral galaxy **NGC 3672**, the brightest and largest member in a loose group of a couple dozen galaxies. Telescopically, the inner region is vivid, measuring 2′ by 1′ in a north-south orientation. Large scopes reveal a thin spiral arm passing east of the core.

On a good night, **NGC 3887** shows off an interesting morphology to visual observers. Northeast of Zeta (ζ) Crateris, it appears at first as a circular haze with a slightly brighter center and some north-south elongation. Using a 13-inch scope at a high and dry site, Arizona observer Steve Coe could see hints of a bar structure in the spiral galaxy.

From NGC 3887, it's a 3.5° pan to the north-northeast to find the elliptical galaxy **NGC 3962**. Although located 85 million light-years away, it is quite bright. Studies at various wavelengths show the stars rotate at a right angle to the rotation of the gas. The visual view shows only the bright, central region. In my 13-inch scope, it is only 1′ across with a slightly brighter center.

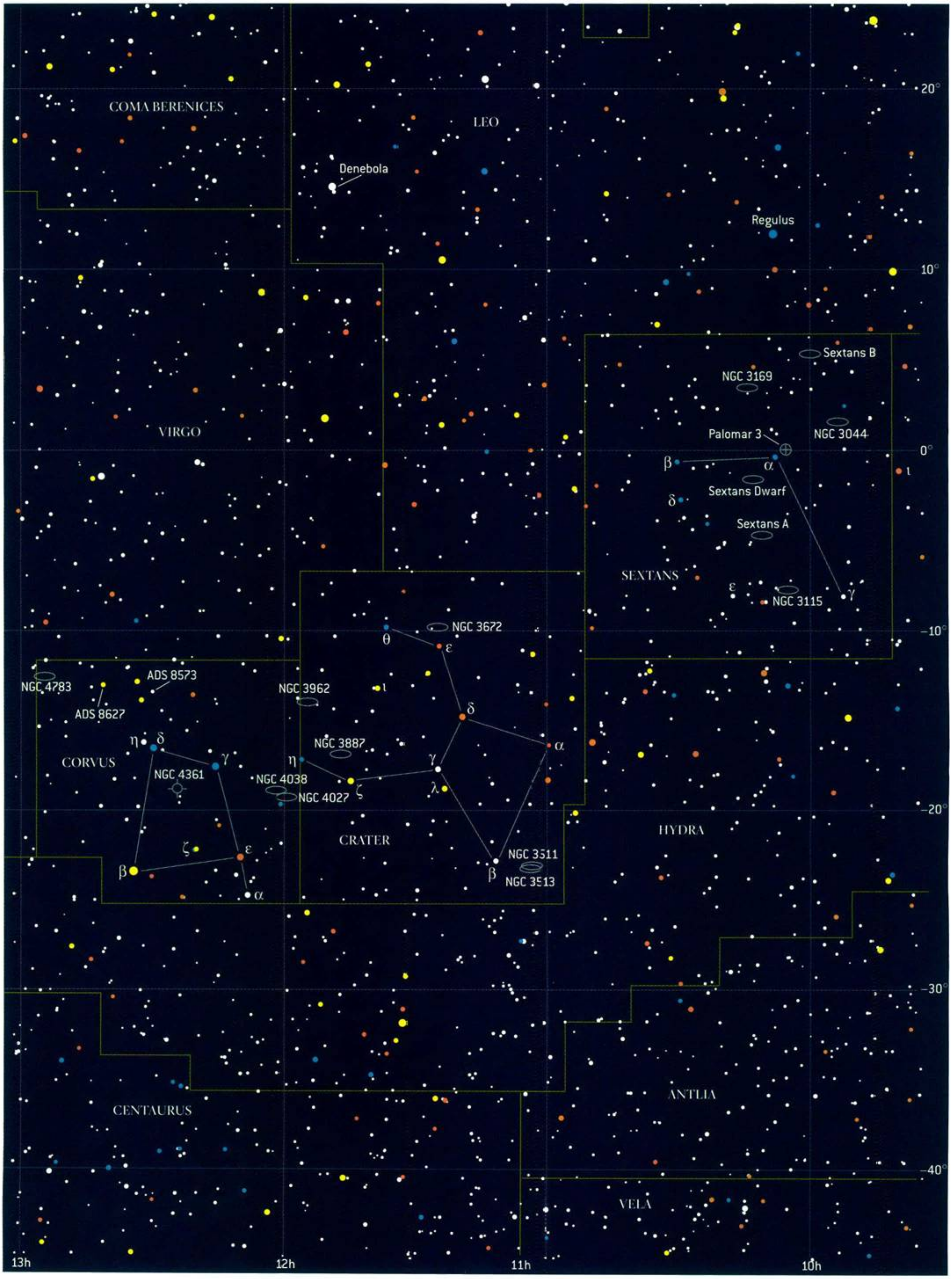
Moving into Corvus, we find the odd, one-armed, barred spiral galaxy **NGC 4027**. Located 30 million light-years away, it forms a loose association with brighter galaxies less than a degree to the east. Its bar is displaced well away from the center, and the end of the bar is pointing nearly straight at us. In a 16-inch scope, the galaxy's peculiar structure is evident. An irregular haze measures 1.5′ by 1′ with a broadly concentrated core. A

/// Deep-Sky Objects in Corvus, Crater, and Sextans

OBJECT	R. A.	DEC.	MAG.	SIZE/SEP.	TYPE	NOTES
NGC 3044	9h53.7m	1°35'	11.9	4.3' by 0.8'	Gal	SB(c)
Sextans B	10h00.0m	5°20'	11.3	5.5' by 3.7'	Gal	IB(s)m
NGC 3115	10h05.2m	–7°43'	8.9	8.1' by 2.8'	Gal	Spindle Galaxy
Palomar 3	10h05.5m	0°04'	13.9	2.8'	GC	
Sextans A	10h11.0m	–4°42'	11.5	5.9' by 4.9'	Gal	IB(s)m
Sextans Dwarf	10h13.0m	–1°36'	12.0		Gal	
NGC 3169	10h14.2m	3°28'	10.2	5.0' by 2.8'	Gal	SA(s)a
NGC 3511	11h03.4m	–23°05'	11.0	5.5' by 1.0'	Gal	SA(s)c
NGC 3513	11h03.8m	–23°15'	11.5	2.9' by 2.3'	Gal	SB(rs)c
NGC 3672	11h25.0m	–9°48'	11.4	3.9' by 1.8'	Gal	SA(s)c
NGC 3887	11h47.1m	–16°51'	10.6	3.5' by 2.4'	Gal	SB(r)bc
NGC 3962	11h54.7m	–13°58'	10.7	2.6' by 2.2'	Gal	E1
NGC 4027	11h59.5m	–19°16'	11.2	3.8' by 2.3'	Gal	SB(s)dm
NGC 4038	12h01.9m	–18°52'	10.5	5.4' by 3.9'	Gal	Antennae Galaxies
NGC 4361	12h24.5m	–18°47'	10.9	45"	PN	
ADS 8573	12h30.1m	–13°24'	6.5/8.6	2.2"	Dbl	Burnham 28
ADS 8627	12h41.3m	–13°01'	6.0/6.1	5.4"	Dbl	Struve 1669
NGC 4783	12h54.6m	–12°33'	11.6	1.8' by 1.7'	Gal	E0

Object: Designation in NGC or other catalog. **R. A. and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds. **Notes:** Hubble types for galaxies.

TOM POLAKIS *is an aerospace engineer who lives in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and astrophotography.*


COMA BERENICES
LEO
Denebola
Regulus
20°
10°
0°
−10°
−20°
−30°
−40°
VIRGO
Sextans B
NGC 3169
NGC 3044
Palomar 3
β
α
δ
Sextans Dwarf
Sextans A
SEXTANS
ε
NGC 3115
γ
ι
NGC 3672
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ε
NGC 3962
ι
δ
α
NGC 3887
η
γ
ζ
λ
NGC 4038
NGC 4027
CRATER
NGC 3511
β
NGC 3513
NGC 4783
ADS 8573
ADS 8627
η
δ
CORVUS
γ
NGC 4361
ζ
ε
β
α
HYDRA
CENTAURUS
ANTLIA
VELA
13h
12h
11h
10h

NGC 4038/39 are interacting galaxies on the verge of a merger and are nicknamed "The Antennae" due to their tidal tails. NOAO/ADAM BLOCK

NGC 3115, also known as the "Spindle Galaxy," is about 35 million light-years away in Sextans. JOHN KORMENDY (UNIVERSITY OF TEXAS)

SEXTANS B is a dwarf galaxy that packs so many stars into one area it is difficult to resolve individual ones. BRYAN MENDEZ

fainter, arcing feature 1′ wide reaches from the west end of the bar to the north. At the east end of this arm is a 14th-magnitude star. Its one-armed spiral pattern is likely the result of an interaction with nearby NGC 4027A, which is present as a half-arcminute smudge 4′ to the south. The complex nature of NGC 4027 earns its place as entry number 22 in Halton Arp's *Catalogue of Peculiar Galaxies*.

Less than a degree to the east-northeast is the nearest example of two galaxies merging. About 60 million light-years away, **NGC 4038** and its companion NGC 4039 are known as "The Antennae" due to their bright tails. They are the result of violent tidal interactions between the two massive galaxies. Along the length of these tails are concentrations of stars that are as large as dwarf galaxies. A 12-inch telescope shows a form that reminds me of a shrimp. The two galaxies' cores are evident, and the light of the pair is spread out over an area about 4′ by 2′. Increased magnification shows the surface to be quite patchy with bright and dark knots. The tidal tails that give the Antennae their name have been seen with apertures as small as 20 inches. If you can see part of them, you can probably trace the entire length, as the surface brightness is fairly uniform from root to tip.

Finally we depart from galaxies to sweep up a planetary nebula inside the prominent figure of Corvus. **NGC 4361** is a near-circular disk with a diffuse edge around a bright central star. The disk is about 1′ across and has a slight east-west elongation. Long-exposure images show an extension to the southwest that may be visible in large telescopes. The nebular shell is highly excited and responds well to nebula filters. NGC 4361 is one of only seven known examples of a quadrupolar planetary — one that has two axes of symmetry, thought to be due to a precessing progenitor star.

Moving the scope 3° north of Delta Corvi brings a tight binary star into view. The components of **ADS 8573** (a.k.a. Burnham 28) are currently separated by more than 2″. A significant brightness difference makes it difficult to resolve. You will need to use a magnification of at least 200x to split the pair. The secondary completes a circuit around the primary every 180 years. It is currently near apastron — its greatest distance from the primary — and will remain so for decades to come.

Now slew 3° to the east to find a much easier double star. The 6th-magnitude components of **ADS 8627** are separated by more than 5″. A small scope at medium magnification easily splits the two, which are a chance alignment. Both stars are spectral type F, which means they appear yellow-white.

Our final object resides in the northeast corner of Corvus. **NGC 4783** and its very close companion NGC 4782 combine into what has been dubbed a dumbbell galaxy. The regions of peak brightness in both massive ellipticals are off-center because each galaxy has perturbed the other. Like the Antennae galaxies, the two exhibit tidal tails, but they can be detected only at radio wavelengths. Seen from a distance of 200 million light-years, the brightness of the pair is impressive. Use your highest magnifications to show the bright overlapping haloes of the two galaxies, which are both just over 1′ across.

/// THE CROW AND THE CUP

THAT thou art blam'd shall not be thy defect
For slander's mark was ever yet the fair;
The ornament of beauty is suspect,
A crow that flies in heaven's sweetest air.
Sonnet LXX, William Shakespeare (1564 — 1616)

The crooked, boxy constellation Corvus looks nothing like a crow; it was probably named so because it lies near Hydra the Water Snake and the cup-shaped Crater. One particular Greek fable involves the god Apollo, a crow, a cup, and a water snake.

As the story goes, Apollo sent a crow with a goblet to fetch some water. On the way, the crow was distracted by a fig tree bearing fruit that was nearly ripe. Not wanting to pass up the delicious meal, the crow waited a couple of days for the figs to ripen. Following his feast, the crow realized he had kept Apollo waiting and that the god would be angry. After filling the cup, the crow grabbed a water snake and brought it to Apollo, saying the snake had tried to prevent him from getting the water. Apollo didn't believe the crow's lie and punished him by putting all three — the crow, the water-filled cup, and the water snake — *into the sky, instructing* the snake to keep the crow from ever reaching the cup. — *Vanessa Thomas*

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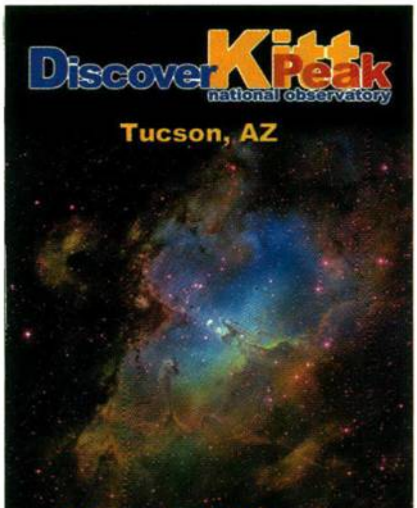

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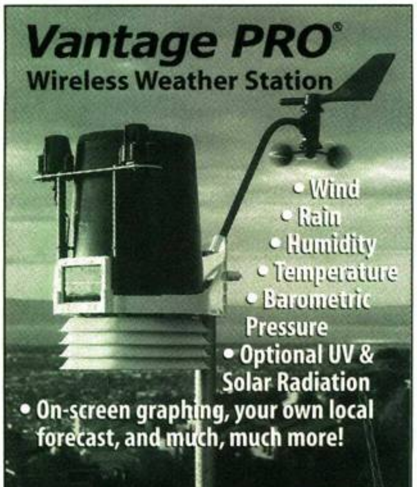

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MARS OBSERVING

Break out your telescope for the best view of Mars you're ever likely to see. /// BY DANIEL TROIANI

NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

Mars — better than ever

Throughout human history, Mars has evoked both fear and mystery. Now it stands poised to blaze into our consciousness like never before. On August 27, 2003, Mars will approach closer to Earth than at any time in the past 59,540 years — so long ago that Neanderthal Man would roam the planet for another 25,000 years. On that date, Mars will also shine brighter in the sky and appear bigger in a telescope than at any time in nearly 600 centuries.

But this apparition is about more than a single day. Mars will appear big and bright all spring, summer, and autumn, delighting observers and the general public alike. The brilliant point of light will only heighten interest fueled in part by recent, convincing evidence that water once flowed on Mars and that large amounts of water ice currently lie just beneath the surface. The launch of several spacecraft in the coming months won't hurt either. The mostly European Mars Express will have both an orbiter and lander, while NASA will be sending two sophisticated rovers to explore the martian surface.

Part of the reason Mars fascinates casual and serious observers alike is that it appears more earthlike than any other planet. It has four seasons like Earth, thanks to the similar tilt of its axis (25° compared with Earth's 23.5°). This drives changing weather patterns, producing clouds of water ice, limb haze, and occasional ground fog. Surface features change in size and color. Some of these changes happen over long periods of time, and many can be predicted.

The annual thawing of the martian polar caps ranks high on the list of interesting phenomena, and it's the easiest to follow in a small telescope. During the 2003 apparition, both caps will be visible, with the southern one more prominent. At first it will appear large, but as the apparition continues, the ices will sublimate until the cap nearly disappears. As the cap thaws, a low cloud deck known as the polar hood may form over the cap.

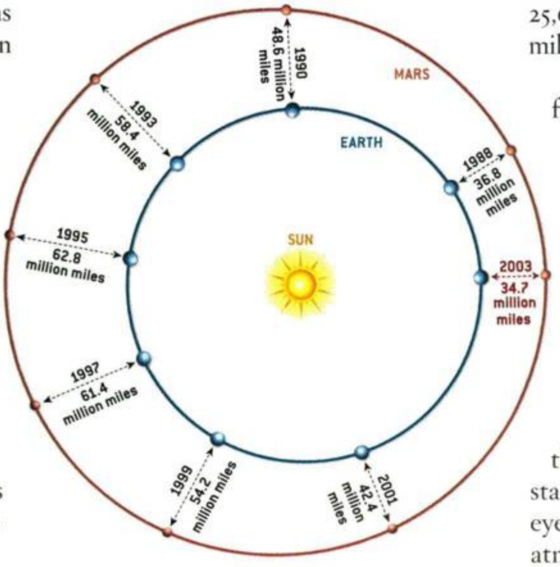
Dust storms may also appear. Usually these remain local events, but they can grow huge and envelop much of the planet in a dusty haze that obliterates most surface markings. Although no one currently predicts a large dust storm for this apparition, everyone's hoping that we don't have a repeat of 2001, when a global dust storm covered the whole planet except for the polar regions.

All the activity this year will play out on a nearly unprecedented scale. Jeff Beish and Jim DeYoung of the Mars Section of the Association of Lunar and Planetary Observers (ALPO) have calculated just how rare this event is. During the 2003 apparition, Mars will be just 34.65 million miles from Earth at closest approach, yielding an apparent diameter of 25.11 arcseconds ("). (That compares with 23.81" during the last great apparition in 1988.) Beish and DeYoung found that Mars will be closer to Earth in 2003 than at any time since the year 57,537 B.C., when it approached within 34.64 million miles and appeared 25.14" across. Mars won't appear larger again until A.D. 25,695, when it will come within 33.45 million miles and appear 26.04" across.

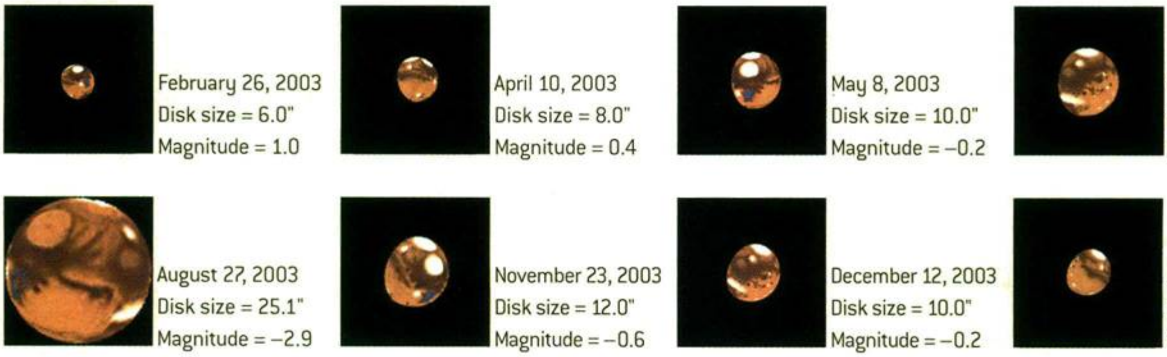
A big disk translates into great views for backyard observers. Mars's penchant for surface changes means you can expect subtle differences almost every time you look. With Mars putting on its best show in our lifetime, you won't want to miss this observing opportunity.

Observing the Red Planet

Even at its best, however, Mars can be an observing challenge. Although the disk appears large by historical standards, it remains diminutive in the eyepiece. And turbulence in Earth's atmosphere can blur its surface markings. Turbulence grows worse the lower Mars appears in the sky because its light must pass through more air. Mars remains south of the celestial equator for most of 2003, hindering observers at



MARS APPEARS BIG AND BRIGHT this year because its orbit brings the Red Planet particularly close to Earth. This apparition ranks as the best during recorded history. ROEN KELLY



THE FACE OF MARS CHANGES throughout this stellar apparition as we view the Red Planet from different distances and directions. Although the peak of the apparition doesn't come until August, significant surface detail will be visible by early spring. DANIEL TROIANI

February 26, 2003
Disk size = 6.0"
Magnitude = 1.0

April 10, 2003
Disk size = 8.0"
Magnitude = 0.4

May 8, 2003
Disk size = 10.0"
Magnitude = –0.2

May 29, 2003
Disk size = 12.0"
Magnitude = –0.6

August 27, 2003
Disk size = 25.1"
Magnitude = –2.9

November 23, 2003
Disk size = 12.0"
Magnitude = –0.6

December 12, 2003
Disk size = 10.0"
Magnitude = –0.2

January 8, 2004
Disk size = 8.0"
Magnitude = 0.3

mid-northern latitudes. In the Southern Hemisphere, however, Mars will stand nearly overhead at its peak.

The finest views of Mars will come with a telescope that provides sharp images with high contrast. Planetary observers generally consider a long-focus, large-aperture Newtonian reflector the best choice, followed closely by a long-focus refractor or Cassegrain reflector. Telescopes with large central obstructions, such as Schmidt-Cassegrains, usually provide lower contrast.

Experienced visual observers — and this apparition lasts long enough that even novices will have time to reach that level — can make out details when Mars exceeds a diameter of 6". The planet reaches that threshold on February 26 and doesn't dip below it again until February 20, 2004. Conventional-film photography requires a disk diameter of 10", a seven-month period lasting from May 8 through December 12. CCD imaging — aided by short exposures that reduce atmospheric turbulence — can record detail at almost any disk size.

Seasoned Mars observers also swear by color filters. Filters increase the contrast of surface and atmospheric features, bringing out detail that would otherwise go unnoticed. They can even make a low-cost telescope perform like a high-end model. For details on what various filters will reveal, see "Color filters for Mars observing" on page 83.

Anyone who observes Mars will find the planet rewarding to sketch. Sketching not only creates a permanent record of what you see, but also helps train the eye and mind to detect elusive detail. To sketch Mars, first draw a circle about 1.5 to 2 inches in diameter. Then start by sketching the location of the terminator — the line that divides day from night. The terminator marks sunset and appears on the eastern limb before opposition; after opposition it represents sunrise and lies on the western limb.

Next, draw either the bright polar caps or the polar hoods above the caps. Then shade in the largest dark markings, placing them on the disk as precisely as possible. (This is a good opportunity to record the time of your observation to the nearest minute.) Next add finer details, using the larger dark markings for reference. Finish the sketch by looking through various color filters, drawing in any ice clouds, dust clouds, or limb haze that you see. Finally, note the date, telescope, image scale, sky conditions, and any filters you used. All this information will prove important if your observation is to be useful.

A day on Mars lasts about 40 minutes longer than an Earth day. That means if you spot a particular feature on Mars's surface one night, the same feature will be 9° farther west at the same time the next night. Forty minutes later, that feature will return to the same position as on the previous night. To know what features will be visible on a certain night, you need to know the central meridian — the imaginary line that passes through the planet's poles and divides the disk into two equal halves. See the map and table on page 82 to determine the central meridian for any date and time.

Surface features of Mars

The dark markings that stand out so prominently on the martian surface are actually vast expanses of rock and dust. Seasonal and long-term changes in these features result from high-speed winds that redistribute the fine layers of dust. Although seasonal variations can usually be predicted, those that occur over longer periods cannot.

The light and dark surface markings tend to change in both albedo — the fraction of incoming sunlight they reflect — and color contrast. Among the regions that display the most dramatic seasonal changes are: Syrtis Major (300° west longitude, 10° north latitude), Solis Lacus (90° W, 30° S), Pandorae Fretum (345° W, 25° S), Nilokeras-Lunae Lacus (60° W, 25° N), Candor-Tharsis (90° W, 10° N), Elysium-Trivium Charontis (210° W, 22° N), Mare Australe (340° W, 65° S), Aonius Sinus (105° W, 47° S), and the Hellas Basin (292° W, 50° S).

Syrtis Major is the most prominent dark area on Mars, and has shown obvious seasonal changes in the past. This wedge-shaped feature — always a favorite target for observers — normally grows larger during the northern hemisphere's summer, reaching its maximum width in mid-summer (early March this year). It then typically shrinks to a minimum in early winter (late October this year). However, recent observations by ALPO observers and the Hubble Space Telescope suggest that no such variations have occurred since 1990.

Also, keep a watch on Solis Lacus, nicknamed the "Eye of Mars," which is notorious for undergoing radical changes. The Trivium-Cerberus region, on the southern rim of the Elysium shield, is another feature of interest to backyard observers and professional Mars researchers alike. For decades, this dark feature measured approximately 800 by 250 miles, but it nearly disappeared during the 1990s.

The Hellas Basin remains one of the most active areas on Mars, not only for its dynamic meteorology but also for its never-ceasing albedo changes. Surface structure becomes apparent when its dark center (Zea Lacus) extends its arms to the north, where they connect Mare Hadriacum (265° W, 40° S) and Yaonis Fretum (318° W, 43° S). As the southern hemisphere's summer solstice approaches (the solstice arrives in late September this year), the basin often becomes inundated with dust when a violent storm begins. During winter, Hellas and the Argyre Basin (30° W, 50°S) often appear a brilliant white; these great basins serve as water-ice reservoirs for the southern hemisphere and often get covered with frost or low-lying clouds.

Martian meteorology

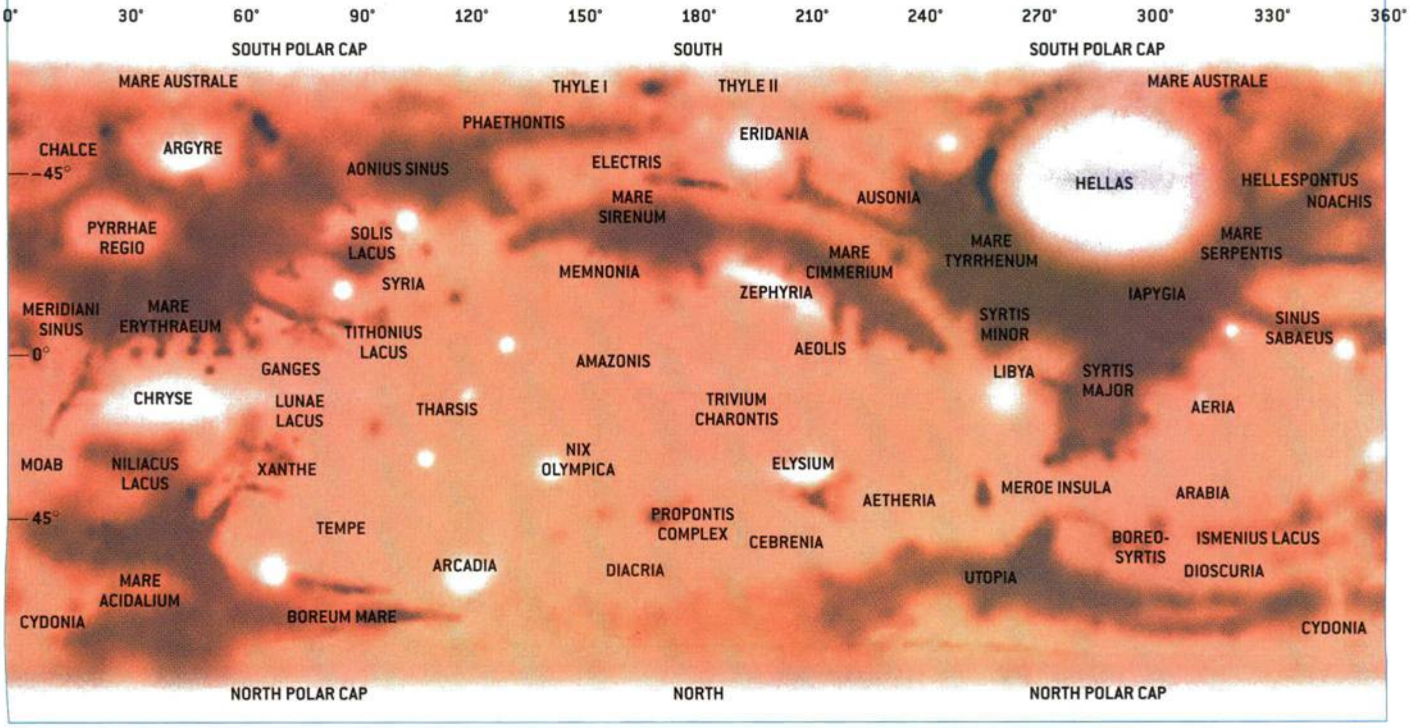
The atmosphere of Mars proves to be surprisingly dynamic, exhibiting conspicuous white clouds of water ice, yellowish dust clouds, bluish limb hazes, and bright surface frosts. The clouds seem related to the seasonal sublimation and later condensation of polar-cap material. A detailed analysis by the ALPO Mars Section of 24,130 observations made between 1965 and 1993 shows that water-ice clouds and surface fog occur more often in the spring and summer of Mars's northern hemisphere than in those same seasons in the southern hemisphere.

Discrete clouds have been observed on Mars since the 19th century. In 1954, observers found a dramatic W-shaped cloud formation recurring each late-spring afternoon in the Tharsis-Amazonis region. A decade later, astronomer Charles Capen proposed that these are orographic clouds, caused by wind passing over high mountain peaks. And in 1971, the Mariner 9 spacecraft showed them to be water-ice clouds near the giant volcanoes Olympus Mons (133° W, 18° N), Ascraeus Mons (104° W, 11° N), Pavonis Mons (112° W, 0°), and Arsia Mons (120° W, 9° S). The W-clouds should be present during the 2003

/// Martian central meridians (CM)

DATE	CM	DATE	CM	DATE	CM	DATE	CM	DATE	CM	DATE	CM
Mar. 1	283°	Apr. 1	343°	May 1	38°	Jun. 1	98°	Jul. 1	172°	Aug. 1	245°
Mar. 8	215°	Apr. 8	261°	May 8	330°	Jun. 8	31°	Jul. 8	106°	Aug. 8	182°
Mar. 15	147°	Apr. 15	193°	May 15	262°	Jun. 15	324°	Jul. 15	41°	Aug. 15	120°
Mar. 22	80°	Apr. 22	125°	May 22	195°	Jun. 22	257°	Jul. 22	336°	Aug. 22	58°
Mar. 29	12°	Apr. 29	57°	May 29	127°	Jun. 29	191°	Jul. 29	272°	Aug. 29	356°

TO FIND SURFACE MARKINGS on Mars, locate a feature on the albedo map below, then use this table to determine when it will lie at the center of the martian disk. It gives the central meridian at 11 P.M. eastern time. To find the central meridian at other dates and times, subtract 9.1° for each day after a tabulated date and add 14.6° for each hour after a tabulated time. *ASTRONOMY*: ROEN KELLY


0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°
SOUTH POLAR CAP
SOUTH
SOUTH POLAR CAP
MARE AUSTRALE
THYLE I
THYLE II
MARE AUSTRALE
PHAETHONTIS
ERIDANIA
CHALCE
-45°
ARGYRE
AONIUS SINUS
ELECTRIS
MARE SIRENUM
AUSONIA
HELLAS
HELLESPONTUS
NOACHIS
PYRRHAE REGIO
SOLIS LACUS
SYRIA
MEMNONIA
MARE CIMMERIUM
MARE TYRRHENUM
MARE SERPENTIS
ZEPHYRIA
IAPYGIA
MERIDIANI SINUS
0°
MARE ERYTHRAEUM
TITHONIUS LACUS
AEOLIS
SYRTIS MINOR
SINUS SABAEUS
GANGES
AMAZONIS
LIBYA
SYRTIS MAJOR
CHRYSE
LUNAE LACUS
THARSIS
TRIVIUM CHARONTIS
AERIA
MOAB
NILIACUS LACUS
XANTHE
NIX OLYMPICA
ELYSIUM
MEROE INSULA
ARABIA
45°
AETHERIA
TEMPE
PROPONTIS COMPLEX
CEBRENIA
BOREO-SYRTIS
ISMENIUS LACUS
ARCADIA
DIACRIA
UTOPIA
DIOSCURIA
MARE ACIDALIUM
CYDONIA
BOREUM MARE
CYDONIA
NORTH POLAR CAP
NORTH
NORTH POLAR CAP

/// COLOR FILTERS FOR MARS OBSERVING

FILTERS HEIGHTEN CONTRAST to bring out detail on the surface and in the atmosphere of the Red Planet. ALPO recommends the following Kodak Wratten filters for Mars observers:

YELLOW (W12 OR W15) Brightens desert regions; darkens both blue and brown features

ORANGE (W21 OR W23A) Increases contrast between light and dark features; penetrates hazes and most clouds; detects some dust clouds

RED (W25 OR W29) Provides maximum contrast of surface features, enhancing fine surface detail, dust cloud boundaries, and polar cap extremities; detects dust clouds or storms (if bright in red and dim in blue, it's dust)

GREEN (W57) Darkens red and blue features; enhances frost patches, surface fogs, and polar projections

BLUE (W80A OR W38) Shows atmospheric clouds, limb hazes, and polar hoods (if bright in blue and dim or invisible in red, it's an ice cloud); darkens reddish features

DEEP BLUE OR VIOLET (W47) Reveals high-altitude clouds; also the standard filter for detecting the mysterious "blue clearing"

MAGENTA (W30 OR W32) Enhances red and blue features and darkens green ones; improves polar region features, surface features, and some clouds

apparition at least until opposition and, perhaps, late in the apparition, during southern spring. Although often seen without filters, they show up best in blue or violet light when at high altitude and in yellow or green light at low altitude. Observers see orographic clouds over the Elysium Shield as well.

Mars also exhibits many localized clouds. These rotate with the planet and most often appear during northern spring and summer in Libya (112° W, 0°), Chryse (32° W, 8° N), and Hellas. One remarkable example is the "Syrtis Blue Cloud," which circulates around the Libya region and across Syrtis Major, changing the color of this dark feature to an intense blue. The cloud usually appears during the late spring and early summer in Mars's northern hemisphere and was prominent during the 1995, 1997, and 1999 apparitions. It shows up best when Syrtis Major lies near the limb.

Light scattered by dust and particles of dry ice high in the martian atmosphere causes limb brightening. These clouds appear most vivid in blue-green, blue, or violet light and should be present on both limbs often throughout this apparition. Sometimes, fine dust mixes in with the clouds, causing them to brighten slightly in orange or red light.

Morning clouds are bright, isolated patches of surface fog or frosty ground seen near the morning limb (Mars's western edge as seen from Earth). The fog usually dissipates by mid-morning, but the frost may persist for most of a martian day, depending on the season. Blue-green, blue, or violet filters best show these bright features. Although evening clouds have the same general appearance, they are usually larger and more numerous than morning clouds. They start as isolated bright patches over light desert regions in the late afternoon and grow as evening approaches.

Dust storms can occur during almost any martian season. The main peak occurs just after Mars's southern summer solstice, but a secondary peak has been observed in early northern summer. The southern summer storms typically grow larger and more dramatic, occasionally enshrouding the whole planet. Such global dust storms are rare, however — only five have been reported since 1873, although all of those have occurred since 1956. Localized dust storms happen much more frequently. They often start in desert regions near Serpentis-Noachis, Solis Lacus, Chryse, or Hellas. To identify a dust cloud, look for a region that appears bright in red light and obscures previously well-defined albedo features.

Normally, the surface features of Mars appear vague through a light blue filter, while a dark blue or violet filter turns the disk featureless except for clouds, hazes, and the polar regions. When a little-understood phenomenon known as the "blue clearing" occurs, however, surface features can be seen and photographed in blue and violet light for several days. The clearing can vary in intensity and may affect only one hemisphere. ALPO encourages Mars observers to watch for this clearing during the 2003 apparition.

Going the extra step

If you catch the Mars observing bug, ALPO wants to hear from you. During each apparition, the ALPO Mars Section receives thousands of individual observations from around the world. These include visual disk drawings made with the aid of color filters, color as well as black-and-white photographs, intensity estimates of light and dark albedo features, color contrast estimates, and micrometer measurements of polar caps, cloud boundaries, and variable surface features. These observations typically cover the entire 10- to 12-month observing period. ALPO has devised a simple form for reporting all types of Mars observations in an efficient way, and photographs can be attached to the top or back of this form.

ALPO also has collaborated with professional astronomers to create the Marswatch program, which allows observers to upload their observations to the worldwide web. Visit ALPO's Mars website at http://www.lpl.arizona.edu/~rhill/alpo/mars.html for more details. There you will find images of Mars contributed by amateurs and professionals, tools to aid you in planning your own Mars observations, current and past issues of the International Mars Watch Electronic Newsletter, and links to other relevant sites.

Obviously, few people will have the time or inclination to sketch or photograph Mars on every clear night. But don't let that discourage you — Mars can and should be observed just for the fun of it. There's no time better than 2003 to experience this magnificent planet.

Daniel Troiani *is Coordinator for the Mars Section of the Association of Lunar and Planetary Observers.*

Xpress
MX916
16 Bit CCD Camera

PHOTO BY WILLIAM ZUBACK

Testing a CCD trio

Three new CCD cameras offer a high-tech alternative to film photography for amateur astronomers. /// BY DAVID HEALY

The CCD revolution in amateur astronomy continues as manufacturers of these digital sky cameras introduce new models that are faster, easier to use, and less expensive than their predecessors. Under a dark Arizona sky, I recently tested samples of three such cameras: the ST-2000XM and ST-9XE models from Santa Barbara Instrument Group (SBIG), and the MX916 from the British supplier Starlight Xpress. Although these cameras could easily be used to photograph planets and the Moon, they are optimized for deep-sky imaging: star fields, nebulae, clusters, and galaxies.

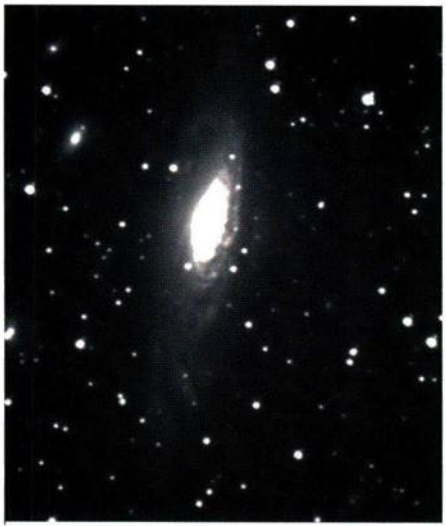
The SBIG cameras

Several of SBIG's cameras, including the two I tested, share almost identical horseshoe-shaped outer shells, with similar cable connections, cooling fins, telescope adapters, and so forth. Each weighs about 2.5 pounds and has a case 5 inches in diameter and 5 inches deep, including the 1.25-inch length of the nosepiece. The cameras operate on 110V AC but can also be operated from a car battery with a 12v power supply or an inverter. The instrument is mounted by inserting one of the supplied nosepieces into the scope's 1.25-inch or 2-inch eyepiece adapter. Both are equipped with standard camera tripod sockets, which can be used to attach the CCD on a telescope equipped with a piggyback mount.

An "open loop," or settable, internal cooling system, equipped with each camera, maintains the instrument's operating temperature at a minimum 30° Celsius below the ambient air temperature. An optional water-cooling system can lower the temperature further. Each camera also has mechanical shutters and utilizes separate imaging and guiding chips — the latter tracks a selected guide star and sends correcting moves to the telescope's drive, while the image accumulates on the main chip. Their USB configurations are capable of downloading images to the computer in six seconds or less. Both come equipped with the Kodak "E" imaging chips, which are notable for their greater light sensitivity (especially to blue light) than earlier generations of chips.

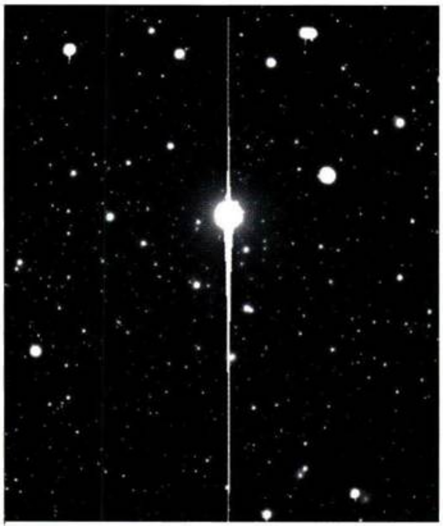
With an undersized 512 by 512, 20-micron pixel display, the ST-9 appears to be designed for a user who is willing to sacrifice resolution for increased light-gathering ability, perhaps for asteroid or supernova searches. The primary difference, however, between the ST-9 and ST-2000 is that the ST-9's imaging chip fails to prevent "blooming." This means that when a bright star in the image oversaturates the detector, the electrical charge generated in the CCD by the star spills out into adjacent pixels, causing streaks or spikes around the bright star's image.

This disadvantage of the ST-9 and other highly sensitive CCDs can be

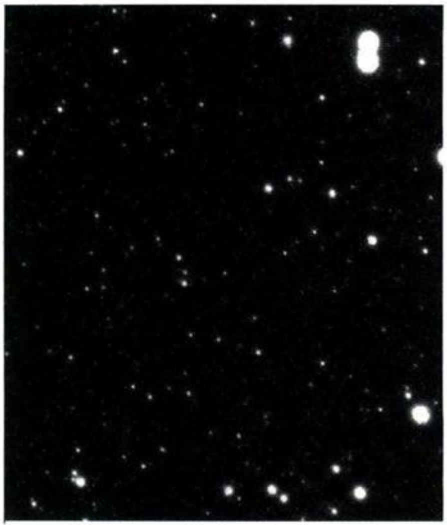


NGC 7331 IN PEGASUS, a bright spiral galaxy discovered in 1784 by William Herschel, was recently imaged by David Healy during an 8-minute exposure with SBIG's ST-2000XM.

IMAGES BY DAVID HEALY



A BLOOMING SPIKE spills across this CCD photograph of Vega, captured by SBIG's ST-9XE. Overexposed stars in CCD images can be repaired automatically with anti-blooming software.



THE "DOUBLE-DOUBLE," (Epsilon Lyrae) featured in the upper right-hand corner of this image, was shot using the Starlight Xpress MX916 while piggybacked during a 20-second exposure.

cleared by corrective software, such as Starizona's Anti-Blooming Filter Software.

The SBIG ST-2000XM's huge 1,600 by 1,200, 7.4-micron pixel array works best where high-resolution images are a priority above high light-gathering ability. Unlike the ST-9, it has an "anti-blooming" imaging chip that suppresses spikes around overexposed star images but sacrifices perhaps as much as 50 percent of imaging sensitivity.

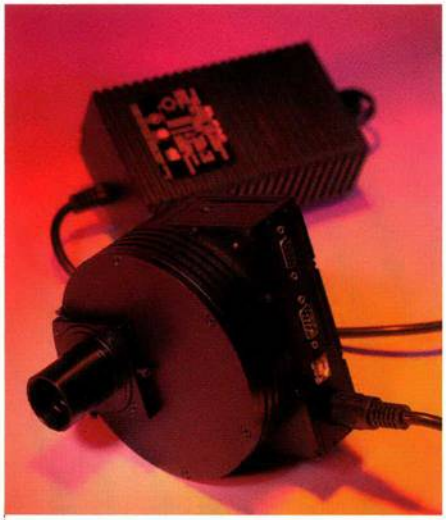
David Healy, *a contributing editor of* Astronomy, *observes under the dark skies of Arizona from his Junk Bond Observatory.*

The Starlight Xpress MX916

This is a capable CCD in a small, light package at a price almost half that of the larger and heavier SBIG cameras. The CCD cylinder is 2.5 inches in diameter and 5.5 inches long, including the nosepiece, which slips into the 1.25-inch eyepiece adapter of your telescope. The camera can also be attached to the "visual back" of Meade and Celestron SCTs by using a T-adapter with universal screw mount threads on the camera side. Its back focus is about 0.7 inch from the rear of the telescope's eyepiece adapter. Like the SBIG cameras, it is equipped with a camera tripod socket, making it ideal for piggybacking on an equatorially mounted telescope with a supplied extender tube. The MX916 will accept old-style (threaded) Pentax and Praktica lenses, but other brands of lenses will require an adapter.

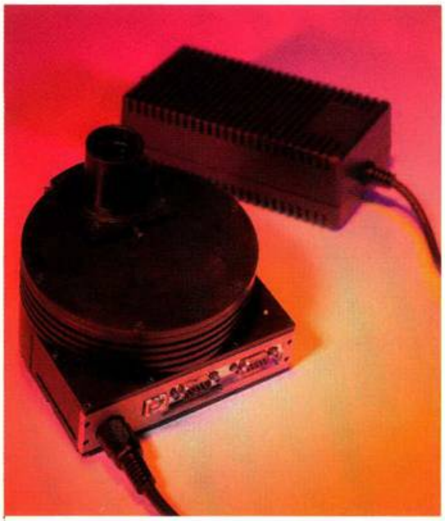
The MX916's "open-loop" cooling element maintains the CCD's operating temperature about 30° Celsius below the ambient air temperature, less of a drop than the SBIG cameras' maximum. However, the MX916's Sony imaging chip enjoys a very low dark current, and the camera's raw images carry so little electronic noise that subtracting a dark frame from many raw

SBIG ST-9XE	Chip Used/Size	Pixel Array	Pixel Size	Field of View	Binning Setting	Street Price
	Kodak KAF 0261E 10.2mm by 10.2mm	512 by 512	20 by 20 microns	17.6' by 17.6' with an 8-inch f/10 scope	1 by 1, 2 by 2, and 3 by 3	$3,695
SBIG ST-2000XM	**Chip Used/Size**	**Pixel Array**	**Pixel Size**	**Field of View**	**Binning Setting**	**Street Price**
	Kodak KAI 2000M 11.8mm by 9mm	1600 by 1200	7.4 by 7.4 microns	20' by 15' with an 8-inch f/10 scope	1 by 1, 2 by 2, and 3 by 3	$3,495
Starlight Xpress MX916	**Chip Used/Size**	**Pixel Array**	**Pixel Size**	**Field of View**	**Binning Setting**	**Street Price**
	Sony ICX083AL 8.7mm by 6.7mm	752 by 580	11.6 by 11.2 microns	14.5' by 11.2' with an 8-inch f/10 scope	1 by 1 and 2 by 2	$1,895



THE SBIG ST-2000XM'S shutters allow the CCD to capture and subtract dark frames without having to cover the telescope or remove the camera.

PHOTOS BY WILLIAM ZUBACK



PIGGYBACKING SBIG'S ST-9XE with a 50mm camera lens provides a surprisingly large field of view of the sky, ranging up to 12° by 9° – large enough to frame Orion's belt and sword, or even the bowl of the Big Dipper.

STARLIGHT XPRESS'S MX916, made of lightweight aluminum, easily slips into the eyepiece adapter of a telescope with a 1.25- or 2-inch nosepiece for imaging through the telescope.

images may not even be necessary. Its USB configuration allows image downloads from camera to computer in less than three seconds. The Sony imaging chip thwarts blooming in an image.

The MX916 lacks a shutter, making it necessary to cover the scope when exposing a dark frame. The camera is self-guiding, but in guide mode it uses one layer of its single CCD chip for imaging and the other for tracking a guide star and sending correction moves to the telescope's drive. The field of view is unaffected, but the loss of sensitivity, perhaps approaching 50 percent in guide mode, must be offset by longer exposures, unlike the SBIG cameras with their separate guiding chips.

The MX916's pixel count (436,000) and pixel size (11.6 by 11.2 microns) are intermediate between the two SBIG cameras, suggesting a reasonable trade-off between light-gathering ability and resolution. It is not as feature-laden as the SBIG cameras, and some users might find it more time consuming than the SBIG cameras for scientific uses such as asteroid hunting or photometry. But it is a powerful instrument in a small and economical package that, with a bit of extra effort, can "do science" as well as take pretty pictures.

Software and connections

Although control software and the cameras can run from your desktop PC, most users of these cameras will, as a practical matter, be found hunched over a laptop screen next to the telescope in the backyard or at a remote observing site. The cameras' software is compatible with Windows 98/Me/2000/XP operating systems. The sizes of the digital images produced by the cameras at their full resolution settings range from 518k for the SBIG ST-9 to 855k for the Starlight Xpress MX916 and 945k for the SBIG ST-2000. So if you plan to save and store numerous images, a capacious hard drive on your laptop is desirable. However, a full resolution image from one of our cameras is still small enough to be saved on a floppy disk and transferred by the notorious "sneaker net" method.

SBIG and Starlight Xpress recently converted their cameras to a USB interface from a parallel port interface, resulting in faster image download times from camera to computer and the ability to use longer and lighter connecting cables. However, the software installation process is complicated, and the instructions must be followed exactly. A critical installation step was left out of an early version of SBIG's otherwise admirable operating manual for its USB cameras: The installer must, if using the Windows 2000, Windows NT, or Windows XP operating system, log on to the computer as "Administrator" when booting up the computer to begin the installation. Otherwise the USB drivers will not operate the camera, and the improperly installed USB drivers are difficult to uninstall. Michael Barber of SBIG says that the current version of its USB-camera manual will include the "log on as Administrator" instruction.

Each camera is supplied with the manufacturer's proprietary camera control software: Star_mx9_USB in the case of the Starlight Xpress unit, and CCDOPS5 with the SBIG cameras. The SBIG cameras also come with CCDSoft camera control software and The Sky mapping software from Software Bisque. Starlight Xpress supplies AstroArt astronomical image processing software with the MX916. However, most of my camera testing was exercised while using MaxIm DL camera control and image processing software from Diffraction Limited. This advanced and versatile software can direct most popular brands of CCD cameras.

Closing shot

CCDs will probably never completely replace film in amateur sky photography, particularly for wide fields of view. However, with cameras such as these, more astrophotographers, especially those based in light-polluted regions, will increasingly embrace the advantages of CCD imaging: advanced light-gathering ability combined with quicker exposures, resulting in instant gratification for the photographer. ■

TECHNIQUES

How to get the most out of your telescope. /// BY PHIL HARRINGTON

Star-test your telescope

How good are your telescope's optics?

Finding out the answer is not as complicated as you might think. You certainly don't need a fully equipped optical laboratory. In fact, all you need are a moderate-power eyepiece and a clear sky. With these, any amateur astronomer can perform one of the most sensitive and telling optical tests available: the star test.

1 Make certain the optics are properly collimated—if they're not, the star-test results won't be accurate. Refractors usually don't need their collimation adjusted, but Newtonians and Schmidt-Cassegrains often do. Check the owner's manual for instructions on how to align your scope's optics.

2 With the telescope collimated and fully acclimated to the outdoor temperature, select a star for the test. The star you choose depends on your telescope. For 4-inch and smaller instruments, select a 1st- or 2nd-magnitude star. Use a 3rd- or 4th-magnitude star for 6- to 10-inch telescopes, while larger instruments may best be tested with a 5th-magnitude star.

3 Use a moderately high-power eyepiece for the test, one that generates a magnification equal to 25x per inch (10x per centimeter) of aperture.

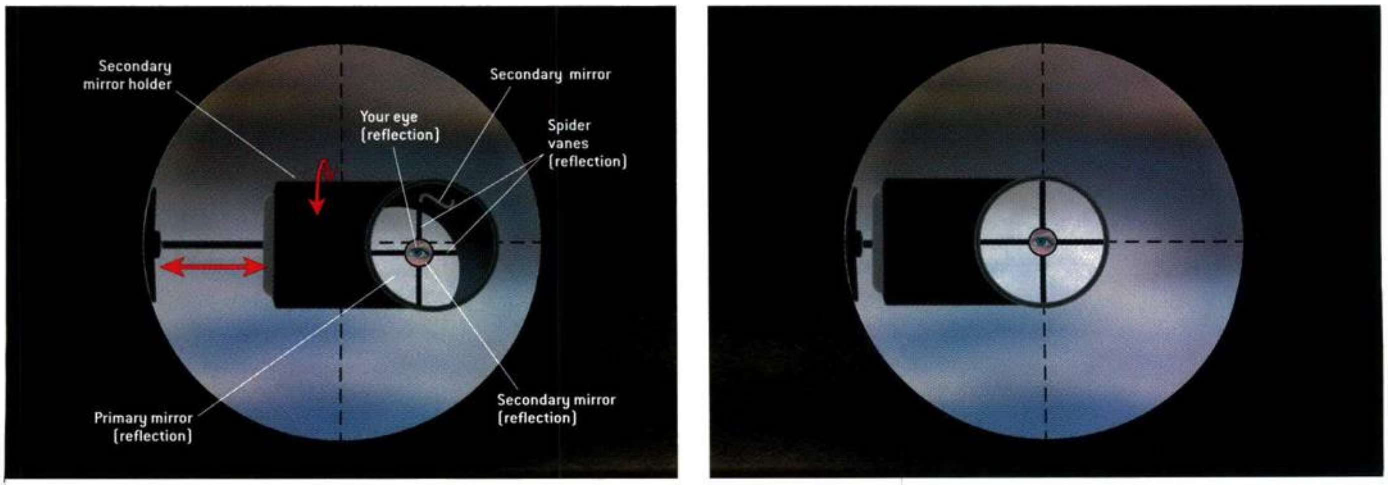
4 Focus the star precisely, then shift its image slightly inside of focus (that is, turn the focuser to bring the eyepiece closer to the tube). Just how far in is a matter of focal ratio. In an f/10 instrument, move the eyepiece no more than 0.2 inch off focus, but in an f/4.5 telescope, move the eyepiece a mere 0.06 inch. The star's light should enlarge evenly in all directions, like the ripples from a stone tossed into a tranquil pond. Remember what the unfocused star looks like, then reverse the focusing knob to bring the star slightly outside of focus by an equal amount. Examine the ring pattern again. If the telescope has first-rate optics, both extra-focal images should appear identical. What if they don't?

If you don't see mirror images on either side of focus, your scope is probably suffering from one of the optical conditions on the facing page.

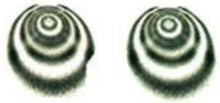
The star test examines all of the optical components collectively, so it can't necessarily tell which is at fault. With a Newtonian, try rotating the primary mirror 90° and retesting. If the defect in the pattern turns with the mirror, then the primary is at fault — otherwise, the secondary is the culprit. In a refractor or catadioptric, try the test first with the star diagonal in place, then without. If things improve when you look straight through the telescope, a new star diagonal should correct the problem.

Follow the simple outline here to find out if your telescope is a dream or a dud. ■

PHIL HARRINGTON *is the author of five books, including the definitive guide to telescopes,* Star Ware *(John Wiley & Sons, 2002).*

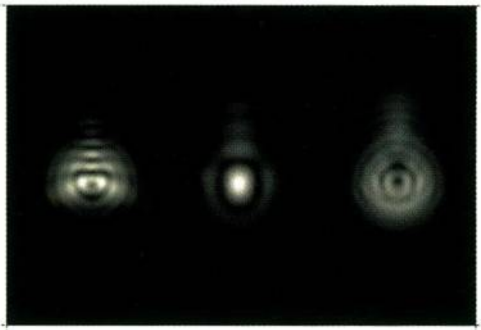

Secondary mirror holder
Secondary mirror
Your eye (reflection)
Spider vanes (reflection)
Primary mirror (reflection)
Secondary mirror (reflection)

EARLY ON IN THE STAR TEST, make sure your telescope's optics are properly aligned, or collimated. To do this, adjust the secondary mirror holder until the reflection of your eye through the focuser lies at the center of a sight tube's crosshairs. *ASTRONOMY*: ROEN KELLY



Collimation

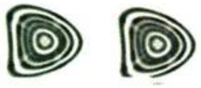
Are the patterns circular? Oval? If the oval shapes look the same both inside and outside of focus, the optics are probably out of collimation, a common occurrence in Newtonian reflectors. Collimating a telescope is not terribly difficult, although it is somewhat time-consuming and involved. You should do it in two steps — the first during the day, when you can clearly see the scope's various inner elements, and the second at night, to check the alignment with the star test. To make sure light travels in a straight line from the primary mirror to your eye, follow the guide in "Collimating a Newtonian Reflector" (August 2002). EDWARD GUERIN



Equilibrium

If the images are dancing wildly, either the telescope optics have yet to adjust to the ambient temperature or the atmosphere is too turbulent to perform the test. Wait at least an hour for the scope to come to thermal equilibrium (possibly longer for 10-inch and larger telescopes) or until the next night for seeing conditions to improve. Setting up on a grassy field will also enhance image quality because the ground absorbs and loses heat more slowly than do parking lots or rooftops. Rising heat perturbs the atmosphere, scrambling the air's refractive index and thereby producing blurry, unstable images.

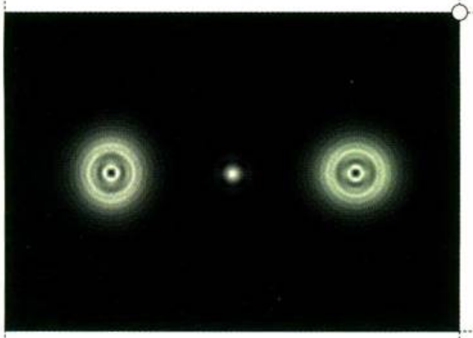
ABERRATOR FREEWARE BY COR BERREVOETS



Pinched optics

What if the images are either triangular or hexagonal? That probably means the optics are being pinched, or distorted, by their mounts. In Newtonians, the clips holding the primary mirror in its cell are often too tight and can be loosened only after removing the primary from the telescope tube. The procedure for mirror removal can vary greatly from telescope to telescope, so consult your owner's manual before proceeding. If the problem still exists after you have loosened the primary mirror, the secondary might be at fault. Check your manual or contact the manufacturer for further instructions.

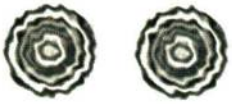
EDWARD GUERIN



Astigmatism

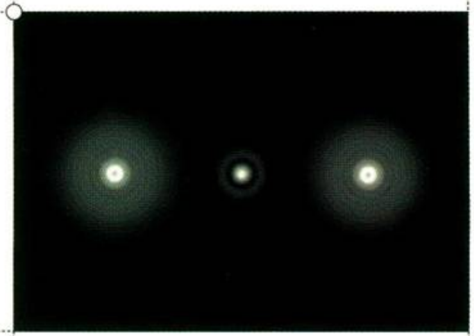
If the defocused images appear oval, move your focuser from one side of focus to the other. Do the ovals flip their orientation 90°? If so, then your telescope suffers from astigmatism, which may result from poorly figured, pinched, or miscollimated optics. If the axis of the star-oval is parallel to the telescope tube, suspect a misaligned secondary mirror, a common problem in Newtonian reflectors that can be checked using a sight tube. The mirror should be centered directly under the focuser, although with 10-inch and larger apertures, it can be slightly offset. In those cases, it is advisable to ask the telescope manufacturer about the offset before adjusting the mirror.

ABERRATOR FREEWARE BY COR BERREVOETS



Rough optics

What if, even when a star is brought out of focus, smooth rings cannot be seen at all? If all you see is a round, mottled blob, make certain the telescope has adjusted to the outdoor temperature. If the image doesn't change over time, your scope is probably suffering from a rough optical surface. More common in reflectors and catadioptrics than in refractors, the problem likely stems from shaping or polishing blunders in the mirror-making process itself. While stopgap measures include blocking the outer rim of the mirror with an opaque material such as cardboard to eliminate some unevenness in curvature, replacing the telescope or optics may be the only long-term solution. Call the manufacturer to ask about the return policy. EDWARD GUERIN



Spherical aberration

The most common optical defect in amateur telescopes is spherical aberration, caused by light from the outer edge of the optic coming to focus at a different distance than light from the center. The upshot is the outer rings of the bull's-eye pattern appear brighter or sharper on one side of focus than on the other. For a Newtonian or catadioptric, the size of the dark center will vary on either side of focus. Unfortunately, this points to an irreparable problem. Contact the manufacturer to ask about the return policy — most companies are willing to replace telescopes with defective optics. Just to be safe, repeat the star test immediately with the new scope.

ABERRATOR FREEWARE BY COR BERREVOETS

TELESCOPE REVIEW

The 5i and 8i take modular design to a whole new level. /// BY STEVE EDBERG

Celestron Nexstars:

Get up-and-go power

Straightforward and expandable, Nexstar telescopes offer the ease of use needed for beginning stargazers. They also provide the versatility and capacity for growth demanded by experienced amateur astronomers. Celestron's youngest generation of Nexstar telescopes includes a new edition of their venerable Schmidt-Cassegrain telescopes (SCTs).

The original Nexstar-i versions are modular, offering a simple electronic hand control. There are no manual slow motions, clamps, or ways to adjust the telescope by hand. Optional features include a computerized hand control and a new CN-16 GPS receiver that automates initialization.

Design: clean and compact

Nexstar telescopes come attached to futuristic-looking sleek, black, curved, single-tine fork mounts. The tubes are silver gray, making for a fine-looking unit. The only factory-shipped accessory on the side of the tube is a "Star Pointer Finderscope." This 1x device (see review, page 94) projects a red dot in the finder to indicate where the telescope is pointed. This finder makes a starhopping reviewer like me nervous — I prefer large magnifying finders that allow faint objects to be quickly located and centered. My experience with these new Nexstar telescopes suggests that a telescopic finder would be a useful addition.

While beautiful, this smooth telescope is not easy to lift. Celestron recommends carrying the instrument by the fork arm and base. The Nexstar 8i weighs about 35 lb or 16 kg and is awkward to maneuver and set up. *Its diameter makes the fork tine difficult* to grip, and there are no chunky features like counterweights to prevent the telescope from sliding out of one's hands.

Celestron's Nexstar tripod is designed so the telescope can be used for altitude-azimuth tracking of celestial objects as Earth rotates, requiring telescope motion around both axes. Nexstars can also be polar aligned using a wedge. In this arrangement, the base of the mount is tilted such that the azimuth axis points through the celestial pole, parallel to Earth's rotation axis. To track celestial objects, only rotation around the azimuth axis, called the right ascension axis in this configuration, is necessary. This mode is accessed via the hand control unit.

The base of the Nexstar mount attaches to the top plate of the tripod with three trapped thumbscrews. The top plate's center rod and three cutouts — used for the rubber footpads on the base of the mount — ease the alignment process. Fingers have room to put the telescope base on the plate without being pinched.

The tripod's adjustable-height metal legs separate by a spreader that has holes to store eyepieces. Unfortunately, the spreader must be removed for the tripod legs to be brought to their fully closed position. I wish Celestron had designed the tripod to allow the spreader to remain attached when the tripod is closed. By forcing users to remove the spreader and its washer and handnut to collapse the tripod, Celestron increased the likelihood that users will lose these pieces. This assembly is the only loose piece to keep track of when the telescope is collapsed.

In the parked position, the 5-inch Nexstar is oriented with the telescope aperture pointed toward the base. This gives the telescope an extra measure of protection during the transport. The 8-inch lacks the necessary clearance to do this, however, and must be stored with the eyepiece down, making the tube susceptible to being pushed by accident. This difference in park position is related to the asymmetry of the telescopes' mount points: the same fork tine is used for the 5-inch and 8-inch telescopes. While the shorter 5-inch can be mounted near its midpoint, the 8-inch telescope's pivot point is much closer to its eyepiece.

Lefthanders, ambidextrous folk, and users of Bausch & Lomb SCTs will appreciate the positioning of a Nexstar-i's focus knob directly beneath the eyepiece holder on the rear mirror cell. Observers accustomed to the older Celestron and Meade SCTs will have to get used to this new, centered position.

Once assembled, I performed "tap tests" with the instrument mounted on the tripod, which showed that the tripod is subject to vibration. Tapping the fork tine generated less vibration than tapping the tripod. In general, vibration shouldn't be a big problem for anyone taking reasonable care not to bump the assembly.

Assembly: straightforward

The initial assembly of a Nexstar-i involves mounting and aligning its 1x, rifle-type LED finder. This is done by loosening, slightly repositioning, and retightening the finder's dovetail plate. The curvature of the 8-inch finder's dovetail plate doesn't match that of the tube assembly, and I expect that over a period of years it will eventually fatigue and break. The finder, but not its base plate, must be removed to place the telescope back in its form-fitting shipping container (an inconvenience from my point of view), but this can be fixed by removing the foam.

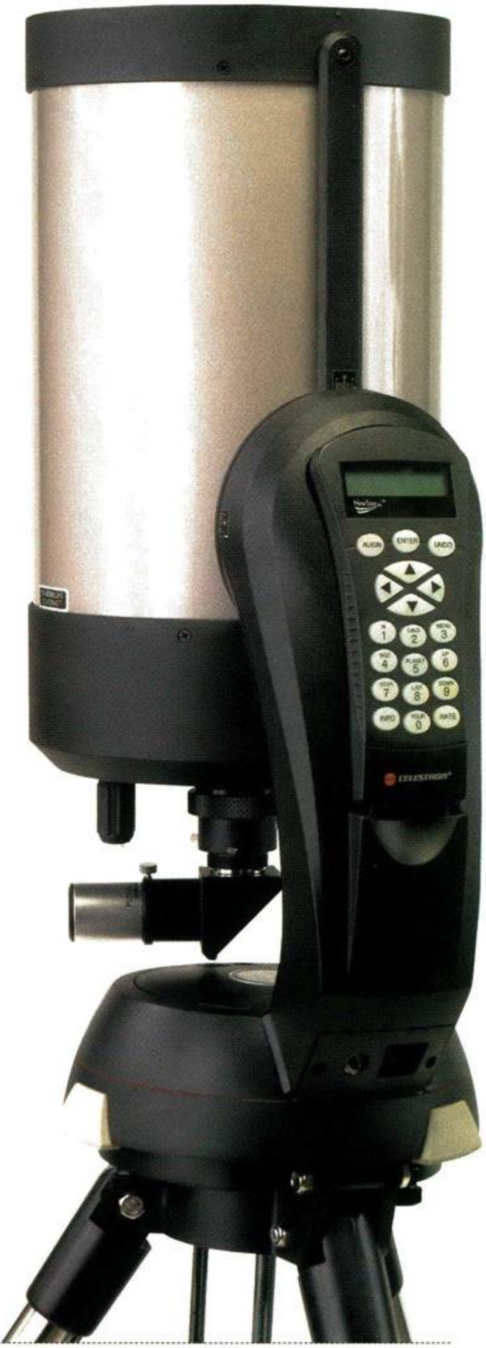
Celestron recommends using the shipping cartons, with their form-fitting foam inserts, for transportation. This will work, but over the long term, the cartons will wear out. A frequent user may want to purchase a Celestron case for their instrument or find a footlocker to hold the telescope and its inserts. The Nexstar 8i will just fit into the commonly available 30″ by 13″ by 16″ footlocker, but owners will have to find their own foam rubber inserts; the shipped inserts won't fit in most footlockers. A case for the Nexstar 5i will not be as difficult to find.

Nexstars can be powered via standard AC current (a wall socket) or with eight AA batteries. A transformer and power cable is provided. Motor speeds are about the same with either power source. With the GPS operating most of the time, an observer can expect a full night's worth of observing from alkaline batteries.

Setup of this instrument is simple — just mount the telescope on the leveled tripod and insert the fully multi-coated star diagonal with a 25mm Plössl eyepiece in the eyepiece holder. Celestron provides thumbscrews on the eyepiece holder and diagonal to help hold things in place. Now you're ready to go.

Control: user-friendly

The Nexstar-i's large fork arm houses the hand control unit or, by removing two screws and an adapter, the computer control unit. The controllers easily pop out



STOWED APERTURE UP WITH AN OPTIONAL COMPUTER CONTROL, the Nexstar 8i telescope's low pivot point limits its park position. This will require an owner to be extra careful when transporting the telescope but does not limit its observational capabilities in any way. The telescope's computer controller can be mounted easily in the fork by removing a small plate. The controller's LCD screen and "UNDO" button make it easy to use, and its 18,000-plus list of objects opens up seemingly limitless observing possibilities.

THE STAR POINTER FINDERSCOPE (mounted upper right on Nexstar 5i tube) is designed for use during initial setup and is not ideal for finding deep-sky objects in unfamiliar fields. The go-to technology prevents this from being too large a problem.

for use and are attached to the arm with a coiled cable that is normally hidden in the arm housing. The coil stretches at least 3 feet (1 meter) and is permanently attached to the hand controls. A telephone-type connector attaches it to the fork arm. The hand controllers do not slip back easily into their housing. I was hesitant to clip them back on the mount during observations because I was afraid of creating vibrations. The best solution seems to be resting the controller on the base of the mount or in the wedge.

Controller inputs are made with a translucent, red-illuminated, soft keypad that clicks when a pad is activated. When testing the scope, there were times when I pushed a key, heard a click, and there was no obvious effect. The Nexstar controller also does not have a marked home key, with raised lettering or another physical indicator to allow it to be used strictly by touch. The keys are separated reasonably well for bare hands, but an observer wearing gloves will need to be careful. An "UNDO" button is provided to correct mistakes easily.

If using the stock hand control for observing, simply set up the tripod with the telescope, making sure it is approximately level, and use the hand control to aim the telescope. A variety of speeds in altitude and azimuth are available.

The computerized hand control has several start-up methods of alt-az alignment. Setup requires the telescope tube to be leveled using index marks provided (and the tripod mounting plate as well, although that is not mentioned in the directions). The degree of leveling required is not stated — is eyeballing it enough, or do I need to use a spirit level? Use a level!

Two-star-alignment is the fastest way to initialize the go-to and tracking systems on these scopes, but it requires observers to identify two stars from the controller's "Named Star" list. The user centers each star in the eyepiece, and presses the controller's "ALIGN" button. After the second star, the controller's screen displays "Alignment Successful" and warns the observer to turn off the finder's red spot — a nice touch. The finder, after all, is not intended for pointing!

Steve Edberg *has been starhopping with jittery, clock-driven telescope mounts since 1966. He is Executive Director of the RTMC Astronomy Expo.*

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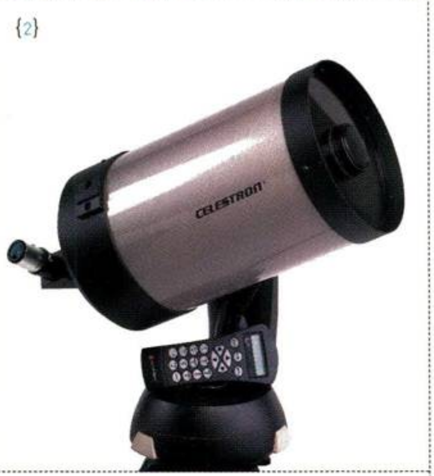


{3}

An auto-align mode is available for observers who don't know star names. The telescope has to be pointed north and the tube should be level; the more accurately done, the more accurate the pointing will be when the alignment is complete. Users will have to enter date, time, and location information. From this data the telescope selects two bright stars for setup. The telescope will auto-slew to each star during setup, and users will have to center the stars in the telescope to complete the alignment process.

I was surprised by the discrepancy between the telescope's pointing and the actual position of the star. I certainly thought my leveling and north pointing were close to correct. The amount of re-pointing that was necessary magnified the necessity of using a leveler and compasses during setup, instead of just eyeballing the initial alignment of these telescopes.

Once the scope was aligned, I could choose from the Nexstar's list of over 18,000 objects to observe, or it could have taken me on a celestial tour. The Nexstars' pointing was sometimes nearly centered, with objects often landing somewhere in the field of view. With the Nexstar 8i, I easily saw a number of galaxies in Virgo that I would never have bothered searching for manually from my home in the foothills above Los Angeles.

Sometimes objects were at the edge of, or even outside, the field of view and required some searching to find. This could be a problem for someone new to astronomy who doesn't know what to look for. I advise adding a 50mm finder to the

1. THE NEXSTAR 5i AND 8i, shown here with optional computer hand control, represent Celestron's youngest generation of Schmidt-Cassegrain telescopes. These sleek new telescopes ship with identical tripods and drive systems.

2. THE STANDARD CONTROLLER offers all the basics — rate adjustments, directional controls, and an all-too-often-important "UNDO" button. The telescope base houses connectors for accessories and power, and the top plate comes off to allow easy replacement of optional batteries.

3. THE DOVETAIL PLATE on the Nexstars can easily be used to mount a magnifying optical finder or other optional equipment, such as a piggyback camera. An observer can add additional plates (not provided) to the 8i, (shown here) by utilizing the screws on the mirror cell.

Nexstar 8i (it has screws on the mirror cell that can be used for this purpose), and a 30 mm or 50mm finder for the Nexstar 5i. Unfortunately, you will have to make a strap to hold the finder on the 5i — there are no extra attachment points on the smaller tube. A finder can also be installed in place of the Nexstars' lx pointer, using their mounting points.

If you point either telescope somewhere in the sky with the hand control, it will track at the rate(s) appropriate to the new position. You can even query the computer to display the telescopes R.A./Dec. — a very useful feature for comet hunters or someone trying to identify a random object spotted in the sky.

> Setup of this instrument is simple just mount the telescope on the leveled tripod and insert the fully multi-coated star diagonal with a 25mm Plössl eyepiece in the eyepiece holder. ... Now you're ready to go.

I found the most accurate telescope alignment could be done with the CN-16 GPS accessory (I used the prototype, not a production version). Apparently, the GPS alignment method uses a version of the two-star alignment method. The telescope came closer to objects when it was GPS-aligned than when I performed the two-star alignment manually.

While the weather was sufficient for testing the telescopes' tracking and pointing, the seeing over several sessions never settled down enough to put the optics through their paces. I can say that the star images in the Nexstar 5i as well as the 8i were crisp, and the level of visible details on planets was limited only by the sky's seeing (amount of atmospheric blurring).

In 3″ seeing, the Nexstar 5i nicely presented Syrtis Major on Mars, and a star's Airy disk had partial rings visible around it. A Ronchi grating produced nice straight lines across a defocused star for both telescopes. The Nexstar 8i presented Saturn with nice optical clarity.

Getting help: the manual

Celestron is to be commended for keeping the instruction manual for the 5i and 8i easy to follow and understand. The manual provides basic information on getting started and using the telescope. I also appreciated the little tidbits Celestron provided, such as a notice about the change in direction of motor motion between slew and set speeds and recommendations on the motor directions to use to avoid backlash when centering an object. In fact, the computerized hand controller offers backlash reduction in its utility software.

The quick set-up section in the manual is followed by detailed instructions. I found them clear and not too wordy, although there were times when I thought that a little more information or better sequencing of information would be desirable. For example, the instructions don't recommend when to align the finder (I recommend daylight or twilight on a distant, identifiable landscape feature). They also don't suggest what to do if the limits of the finder's motion are reached before it can be centered on the feature (first, try loosening the screws of the dovetail plate and moving the plate before retightening; then disassemble the plate or add a shim if that didn't work). Do I go to R.A./Dec. mode in the controller before or after aligning that way? Based on experience, I'd say after.While experience allowed me to use this telescope without difficulties, a beginner may face a trying trial and error period.

The manuals have good summary sections on telescope basics, polar alignment, celestial motions, observing, astrophotography, and telescope maintenance. Along with a glossary, instructions are provided for using the telescopes' RS-232 ports for external computer control.

The manuals also include a table of latitudes and longitudes in the United States. There were many listings for California, but a few obvious ones were missing. I can't judge the lists for other states as well, but users anywhere will want to get their latitudes and longitudes from a topographic map, atlas, or Global Positioning System receiver to achieve better results. Simple star charts in the Nexstars' manuals indicate major constellations (some with uncommon presentations of their shapes), and some of the stars on the "Named Star" list in the instruments' database are named and circled on the charts to assist in setup for inexperienced observers.

As always, users should follow the directions in the manual. The joy of these telescopes, though, is that they are so user-friendly. The controller presents instructions, "UNDO" is easy, and operation is intuitive. After following the manual a few times, a user will have learned everything necessary to operate the telescope without having to review the directions.

A few parting remarks

Some of my hesitation with pushbutton, computer-driven astronomy has to do with the difficulty of setting up computer-controlled telescopes and getting their software initialized and running. This is especially relevent for infrequent and occasional observers. Celestron's Nexstar telescopes have effectively deflated that concern. The careful ergonomic engineering and user-friendly control system make these telescopes a pleasure to use. In just minutes a user can be set up and observing objects that would otherwise be hard or impossible to find. While I still think astronomers should know the sky, the Nexstar has convinced me that an easy-to-use computer-controlled telescope is now available and that it is a fun and efficient way to observe. Now, when can I get a 14-inch or larger one?

PRODUCT INFORMATION

Nexstar 5i	$1,630 list
Nexstar 8i	$2,150 list
Nexstar Tripod	$99 retail
Computerized Hand Control	$250 list
CN-16 GPS Accessory	$298 list

Street prices are considerably lower.

Celestron International
2835 Columbia Street
Torrance, CA 90503
http://www.celestron.com

EQUIPMENT ROUNDUP

Rediscover one of astronomy's most useful accessories. /// BY JOHN SHIBLEY

Focus on finders

I'm the first to admit a love for go-to computerized telescopes. Even a rank beginner can slew in target after target like a pro. Indeed, this is how professional astronomers find the objects they study. So the question naturally arises, why even bother with telescope finders at all? It's almost as if they've become — to stretch a metaphor — an astronomical appendix.

But don't count the venerable finder out quite yet. For one thing, in a very practical sense, it supplements a smart telescope. A finder is the proverbial parachute you can always rely upon when electronic gadgets don't work smoothly. If all else fails, you can use a finder to physically point a telescope toward what you want to observe.

In addition to these and several other compelling reasons for using a finder (see "Top seven reasons to use a finder," page 98), there's never been a better selection of finders on the market. Let's meet a few finders that are grouped by design.

Reflex or one-power finders

These are finders inspired by heads-up displays and pistol sights. What sets them apart from traditional astronomical finders is that they do not magnify the sky at all. These finders project a red dot or bull's eye pattern onto a small, clear, acrylic (or in the case of Tele Vue's Starbeam, glass) window that you sight through toward the sky. The utility here is that the pointing dot or pattern is superimposed along your line of sight with the sky. With a properly aligned reflex finder, the dot marks exactly where the telescope is pointing.

John Shibley *uses finders to feel his way through the dark under the Upper Michigan skies. Watch these pages for his new celestial imaging series.*

RIGEL SYSTEMS QUICKFINDER

[$37.95; extra base, $6.95]
Rigel Systems
26850 Basswood Avenue
Rancho Palos Verdes, CA 90275
[t/f] 310.375.4149 [e] rigelsys@cox.net
[w] http://members.cox.net/rigelsys/rigelsys.html

Rigel's reflex finder stands taller (4 inches), but takes up less telescope tube area than any other finder in its class. A rugged PVC housing encloses a 1¼- by ⅞-inch acrylic viewing window, making it less susceptible to dew.

A reticle in Quickfinder's housing projects a two-circle, concentric pattern onto the viewing window. The inner circle subtends ½°; the outer circle, 2°. A flat 3-volt lithium battery powers the pattern's red LED. This little battery can keep the LED lit at full power for an astonishing 38 continuous hours. The housing's forward face has an oversized power switch that also adjusts the LED pattern's brightness. Three identically sized white nylon hand nuts are used to align the pattern with your telescope. A fourth narrow white nut, next to the power/brightness switch, changes the LED pattern flash and also adjusts the blink rate.

A snap-lock button lets you quick-disconnect the finder and snap it into another telescope-mounted base. Quickfinder weighs less than three ounces and ships with two bases.

TELRAD FINDER

[$40; extra base, $7.95]
Telrad, Inc.
8461 Seal Beach Dr., Reno, NV 89506-3166
[t/f] 775.677.0930
Available worldwide through dozens of dealers

This product started the reflex finder revolution in the late 1970s. Its inventor, the late Steve Kufeld, built his prototype from a gun sight he purchased through a World War II surplus catalog. The Telrad hasn't changed at all over the past quarter-century. If anything, its beefy PVC housing (7¼ inches long, 1¾ inches wide, and 4 inches tall on the window end) has lost a little weight. My vintage finder, purchased in 1981, weighs almost a pound, while a review unit weighs a mere 8 ounces.

Telrad has the largest acrylic viewing window of any reflex finder on the market: 2½- by ½-inches. A red LED bull's eye reticle inside the housing projects a pattern of three concentric circles (covering ½°, 2°, and 4° of sky) onto the clear window. A levered, rotating power switch on the housing's side also adjusts the pattern's brightness. Three hand-nuts on the back align the pattern with your telescope's aim. Telrad's "Pulser" switch kit ($20) lets you retrofit the finder so its pattern pulses. Two AA-sized batteries can keep the pattern lit for 23.5 continuous hours.

As is, the exposed window is vulnerable to dew. Telrad offers a dew shield ($13) that hinges over the window. A deluxe hinged dew shield ($25) incorporates a mirror that lets you view the bull's eye pattern from above. Kendrick Astro Instruments (www.kendrick-ai.com) sells custom-sized electrical heating pads ($24) to keep moisture off the finder. Kendrick also markets a solar projector plate (Sun Finder, $30) that lets Telrad pull double duty as a solar finder.

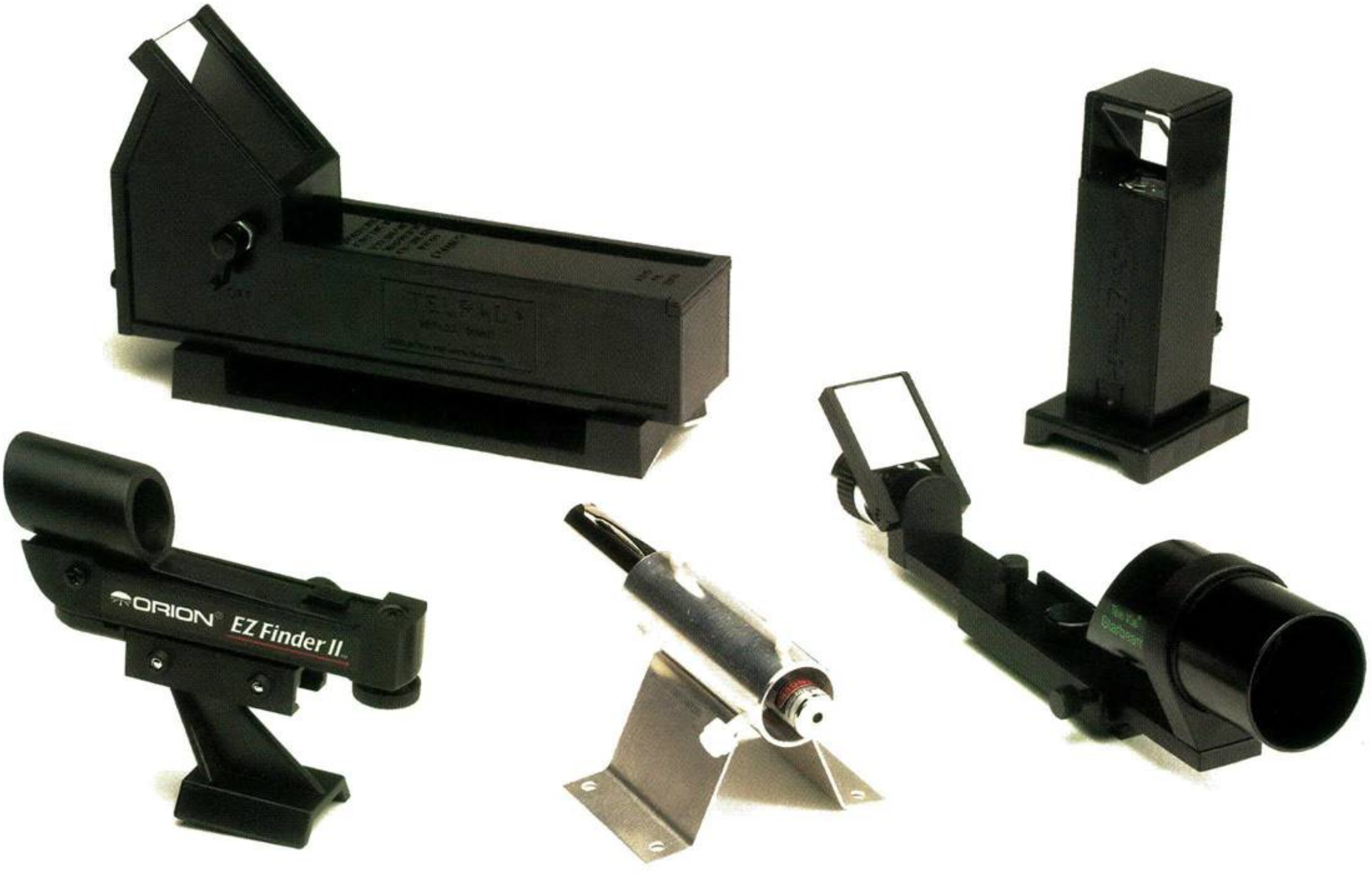
ORION EZ FINDER II

[$34.95 Includes universal mounting plate
Bracket for Schmidt-Cassegrain telescopes, $8.95]
Orion Telescopes & Binoculars
89 Hanger Way, Watsonville, CA 95076
[t] 800.676.1343 (toll-free customer service)
[f] 831.763.7024 [e] support@telescope.com
[w] www.telescope.com

This red-dot, unit-power finder is a direct descendent of the Daisy air gun sight. A pinpoint LED projects a red dot onto a ⅞-inch wide acrylic window you sight through. EZ Finder II features ⅝-inch knobs to align the red dot's lateral and vertical position in the window. A rotating power switch also adjusts dot intensity. In the dark, I often confused it with the marginally larger lateral alignment knob. EZ Finder's 3-volt lithium battery keeps the LED lit for 20 hours. There are other red-dot finders on the market, but none incorporate all of EZ Finder II's features. ScopeTronix's Light Sight ($24.95; www.scopetronix.com) is identical, but lacks an adjustable light source. Tele Vue's Qwik Point ($39;

/// Finder scopes compared

	NAME	MANUFACTURER	PRICE	DESCRIPTION	POWER	NOTES
REFLEX OR ONE-POWER	**Quick Finder**	**Rigel Systems** 26850 Basswood Avenue Rancho Palos Verdes, CA 90275 310.375.4149	$37.95 extra base $6.95	1 ¼- by ⅞-inch acrylic viewing window with illuminated bulls-eye [½° and 2° circles].	3-volt lithium battery 38 hours	Ships with two bases. A quick lock snap allows easy interchange between scopes.
	Telrad Finder	**Telrad, Inc.** 8461 Seal Beach Dr. Reno, NV 89506-3166 775.677.0930	$40.00 extra base $7.95	2 ½- by ½-inch acrylic viewing window with illuminated bulls-eye [½°, 2°, and 4°].	Two AA batteries 23.5 hours.	Editor's favorite. Combined with an optical finder, you can find anything.
	EZ Finder II	**Orion Telescope & Binoculars** 89 Hanger Way Watsonville, CA 95076 800.676.1343	$34.95 Schmidt-Cass. Bracket $8.95	Red pinpoint projected on ⅞-inch wide acrylic viewing window.	3-volt lithium battery 20 hours	Can adjust dot intensity. Comes with universal mounting plate.
	Starbeam	**Tele Vue Optics** 32 Elkay Drive Chester, NY 10918 845.469.4551	$205	Red pinpoint projected onto a glare-resistant 1½-inch diameter piece of glass.	Two 1.5-volt lithium batteries 26 hours	
OPTICAL	**8x50 Amici**	**University Optics** P.O. Box 1205 Ann arbor, MI 45106-1205 734.665.3575	$179 dovetail base $36.95	Rectified 8x finder scope with crosshairs that accepts standard 1½-inch eyepieces.	N/A	This is the Cadillac of optical finder scopes.
	9x50 / 6x30 Corrected-Image Finder	**Orion Telescope & Binoculars** 89 Hanger Way Watsonville, CA 95076 800.676.1343	$76.95 / $49.95 dovetail base $8.95	Rectified 8x and 9x finders with crosshairs. Mounts easily to standard dovetail plates.	N/A	Right angle prism and eyepieces do not come out.
SOLAR	**Sol Searcher**	**Tele Vue Optics** 32 Elkay Drive Chester, NY 10918 845.469.4551	$30	A hole in a disk projects the Sun onto a second disk. Align the Sun's light on a marked disk, and you should be ready to go.	N/A	Easy to attach (double-sided tape works). Easy to use. Very small. May fit into an eyepiece case.
	Sun Finder	**Kendrick Astro Instruments Retail Inc.** 2920 Dundas street west Toronto, ON M6 1Y8, Canada 800.393.5456	$30	A small hole projects the Sun on the back wall where a marker can be aligned for your telescope.	N/A	Can be permanently mounted on a Telrad finder. Sturdy and easily aligned.
OTHER	**Sky Pointer Green Laser**	**Howie Glatter** 3850 Sedgwich Ave. Bronx, NY 10463 718.796.3203	$184 bracket $35 remote $30	A green laser light acts like a laser sight on a gun.	Two AAA batteries	Side benefit: Laser light illuminates dangerous conditions such as dust and fog that you may otherwise miss in the darkness.



REFLEX OR ONE-POWER FINDERS AND A LASER Clockwise, from upper left: Telrad, Rigel System's Quick Finder, Tele Vue Optics' Starbeam, Sky Pointer by Howie Glatter, and Orion's EZ Finder II. These finders do not magnify the sky but project laser-light targets that allow observers to point their telescopes using a "point and view" approach. *ASTRONOMY*: WILLIAM ZUBACK

www.televue.com) and Celestron's Star Pointer ($39; www.celestron.com) don't have red-dot adjustment thumbwheels. Tele Vue does offer a board that slips into the Qwik Point's battery port to set the dot's brightness at two intensities.

TELE VUE STARBEAM

[$205] Specify universal (with mounting plate) or Tele Vue telescope version
Tele Vue Optics
32 Elkay Drive, Chester, NY 10918
[t] 845.469.4551
[w] www.televue.com
Available worldwide through dozens of dealers

Every feature in the Starbeam optimizes the reflex finder philosophy. The glass finder window is an oversized 1½ inches for maximum visibility. Coatings on the window, as well as its slightly curved shape, reflect the finder's red dot without picking up spurious reflections. This makes Starbeam's red dot easier to see than that of any other reflex finder I've seen on the market. The finder's optical window is also shielded from glare and dew inside a 2¾-inch cylindrical housing. Lens caps protect the window when the finder is not in use. A two-section base plate has knobs for horizontal and lateral adjustment. A large center knob locks alignment. Two 1.5-volt batteries power the LED dot source for 26 straight hours. A knurled power switch on the chrome housing also adjusts the dot's intensity. A small mirror hinges over the LED housing to let you sight the red dot on the field window at right angles to the finder, rather like an eyepiece diagonal on a telescope. This comes in handy with scopes that stand lower, or when searching for targets that are higher up in the sky.

Optical finders

Also called "finder scopes," these finders slightly magnify the view with a lens. Crosshairs mark the field center. The first part of the label refers to the magnification, while the second part conveys the front lens's diameter in millimeters. For example, "9x50" means the finder works at 9 power with a front lens 50 millimeters wide. A bigger lens sees fainter stars and targets with greater detail.

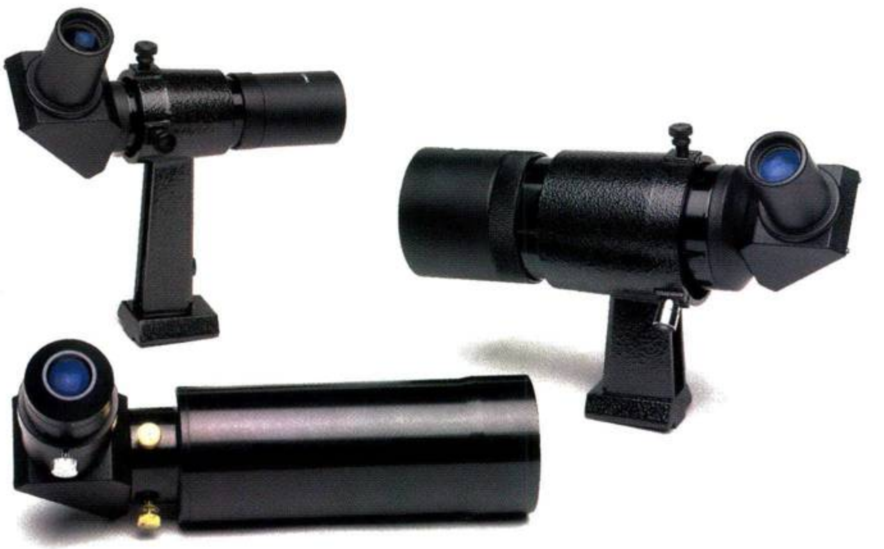
Finder scopes offer views straight through or, with a right-angle diagonal, from above. "Amici" or "corrected-image" optics create properly-oriented images. Finders today almost universally come with glare-reducing lens coatings.

Magnifying finders provide the benefit of showing fainter field stars around targets and work well with binocular searches.

UNIVERSITY OPTICS 8X50 AMICI FINDER

[$179; bracket w/dovetail base, $36.95]
University Optics, Inc.
P.O. Box 1205, Ann Arbor, MI 45106-1205
[t] 734.665.3575; 800.521.2828 (toll-free)
[f] 734.665.1815 [e] uoptics@aol.com
[w] www.universityoptics.com

Materials, design, and construction set this finder apart from others on the market. The housing, diagonal, and the diagonal's set-screws are all metal. A two-element main lens offers crisp and sharp images.



OPTICAL FINDERS Clockwise, from upper left: Orion 6x30, Orion 9x50, University Optics' Amici 8x50. These finders show magnified views of the sky that are rectified to allow easy telescope pointing. Each finder has non-illuminated crosshairs for centering. *Astronomy*: William Zuback

Most finders focus through a threaded sleeve that twists and minutely moves the objective lens. (Adjusting for focus comes in handy between different observers' eyes or if sighting an object on land.) This runs a greater chance of jostling the finder out of pointing alignment. University's finder focuses by loosening brass set screws and sliding the right-angle diagonal back and forth. Best of all, this is the only generic finder on the market with an 1¼-inch eyepiece. This conventionally sized, crosshair eyepiece is easier to view through than some of the somewhat narrower views afforded by eyepieces of a smaller barrel diameter. Because it's made of brass and anodized aluminum, the University Optics 8x50 does weigh in a bit heavier than most, at 18 ounces. But it's the Cadillac of finders in its class. The Amici-type finder serves up properly oriented images; University also offers a non-rectified version for $54 less.

ORION 9X50/6X30 CORRECTED-IMAGE FINDER

[9x50 $76.95, 6x30 $49.95, Each ships with dovetail-foot bracket; dovetail base plates, $8.95]
Orion Telescopes & Binoculars
89 Hanger Way, Watsonville, CA 95076
[t] 800.676.1343 (toll-free customer service)
[f] 831.763.7024 [e] support@telescope.com
[w] www.telescope.com

These two units represent the best value in optical finders. Each is fitted into a single-sleeve bracket that adjusts the alignment with two thumb knobs that pivot against a spring-loaded pin. It wasn't all that long ago that cumbersome adjustments required twisting three knobs at once, each to a varying degree. Wider adjustment knobs would make alignment easier through gloves. The bracket fits the dovetail plates found on most scopes today. Both units exhibit a remarkably wide, relaxed field of view

/// TOP SEVEN REASONS TO USE A FINDER

1 Get a feel for the sky's scale. Scroll-and-slew observing runs the risk of distilling the sky's grandeur down to a set of data and numbers. Calling the Andromeda Galaxy, M31, up through a go-to telescope — versus actually locating it visually in the sky with a finder — almost conceals the subtlety of its sheer size. Under a dark sky, M31 spans the width of eight Full Moons. This hit me for the first time after I compared its glow — through a finder with crosshairs — with the relative size of a setting crescent Moon.

2 Astronomy involves looking. The first tentative steps taken by any astronomer, even budding astrophotographers, are firmly visual. Fundamentally, we desire to glean things with our own eyes. Don't pass up any chance to eye the sky through a finder, binoculars, or telescope. It keeps you connected with the sky at all times and at many levels.

3 Low-tech and long lasting. Finders never slow down or shut off for lack of electricity. They're natural power misers, some requiring no batteries at all. Finders embody the ultimate in simple technology.

4 A way to appreciate the night sky. If life's a movable feast, why pass up another enjoyable perspective on astronomy? Finders open a whole other dimension of sky appreciation. They fold the invisible universe into naked-eye constellations. It's not so much that Leo and Virgo splay across a spring night sky. In the mind's eye, the Coma-Virgo galaxy cluster scatters throughout those constellations as well. Rather than asking, "How faint can I see through a finder and with the unaided eye?", you should be asking, "How faint can I visualize?" A "finder" train of thought leads to this abstraction.

5 Acquire a context for the sky. Finding targets visually puts all of the sky's pieces together into a whole. Rather than dialing in glowing gas clouds along the Milky Way, locating them with a finder actually conveys their distribution along the plane of our home galaxy.

6 Transition between eye and telescope. It's often said that binoculars serve as a bridge between observing the sky with unaided eyes and using a telescope. Finders cement that bridge further. They offer a seamless transition between seeing a constellation, visualizing the target's location in the constellation, confirming its general location in a field of nearby stars, and perhaps actually glimpsing it with the slightest visual aid. All this before bringing the resolving power of an astronomical telescope to bear.

7 Enhance valuable star-patterning skills. A go-to scope lands you in a star field that includes Pluto. Now what? No matter how smart the scope, it all comes down to mentally comparing star patterns against a finder photo or map until a starlike interloper stands out. Either that or sketching a field and checking in a day or two later to see which "star" moves against a fixed backdrop. Locating the unseen in a field of the seen is a simple yet powerful skill that *finders foster. Through a finder, nearby stars fall* into geometric patterns that bracket, center, or lead to a target object. — *J.S.*

and generous eye relief — an essential for eyeglass wearers. The right-angle prism and its eyepiece don't detach. While I'm not a fan of the front-element focus design, I found that a lock ring allowed this objective sleeve to twist smoothly and stay put.

Special-purpose finders

These devices don't fall into any of the categories above. Two finders solve a problem every solar observer has grappled with at one time or another. The other may usher in a new era of night finders, just as the Telrad did 25 years ago.

TELE VUE SOL SEARCHER

[$30]

Tele Vue Optics

32 Elkay Drive, Chester, NY 10918
[t] 845.469.4551 [w] www.televue.com
Available worldwide through dozens of dealers

Finding the Sun with a solar filter-fitted telescope is harder than you think, but it is easier with this handy little solar finder marketed by Tele Vue.

Sol Searcher is an anodized black aluminum finder only 2¼ inches long with 1¼-inch diameter circular plates on each end. The front plate has a hole for the Sun and casts a shadow on a back plate that has a small, circular, white projection screen. Line up the front hole's projection on the back plate's screen, and the Sun should be in the field of view of your telescope. Sol Search is slotted to fit the finder plates found on Tele Vue telescopes, but I just removed two hex studs on the finder's base and stuck it to my telescope with nothing more elaborate than double-stick tape.

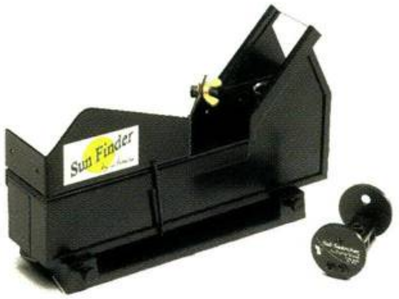
SUN FINDER

[$30]

Kendrick Astro Instruments

2920 Dundas Street West
Toronto, ON M6P 1Y8, CANADA
[t] 416.762.7946; 800.393.5446 (toll-free)
[f] 416.762.2765
[e] Kendrick@kendrick-ai.com
[w] www.kendrick-ai.com

Kendrick Astro Systems markets this solar projector plate that lets the popular Telrad reflex finder pull double duty as a solar finder. Sun Finder slips on top of the Telrad's forward housing and secures with a bungee attach-strap. The strap will also fit telescope tubes up to 3 inches in diameter. A pinhole on the finder's front plate, located between two larger holes, projects a solar image onto a rear plate. When all three projections appear at once, the Sun should be in the low-power field of a telescope. A brass clip on the back plate lets you mark the pinhole projection's location, thus calibrating the finder for next time. I also clipped a lighter-colored card into place to see projected images better.



SOLAR FINDERS On the left is the Sun Finder by Kendrick Astronomical Instruments (shown on a Telrad finder, sold separately) and on the right Tele Vue Optics' Sol Searcher. These finders remove the danger factor in finding the Sun with your telescope. *ASTRONOMY:* WILLIAM ZUBACK

SKYPOINTER GREEN LASER

[$184; mounting bracket, $35; remote kit, $30]

Howie Glatter

3850 Sedgwich Ave., Bronx, NY 10463
[t/f] 718.796.3203
[e] howieglatter@mindspring.com
[w] www.skypointer.net

I first purchased SkyPointer to use as an educational aid at star parties. Its powerful 5-milliwatt light is polarized so you and everyone else in the area can see the beam. The beam stays so focused, in fact, that I've used it for binocular tours. The laser activates with a push-button switch, so it turns on only when you need it. I've found that two AAA batteries power it for about six full nights of rigorous use. The beam gets harder to see as battery power lags. Now Glatter offers aluminum brackets that mount the green laser on a telescope. Point the beam to point the scope. A remote switch kit quickly (and temporarily) retrofits the laser so it can be activated through a switch on the telescope tube or near the focuser for greater convenience. The remote connects to the laser through a two-foot cord. ■

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Picture taken with TSN-824 Scope DA-1 Adaptor and Nikon Coolpix 995

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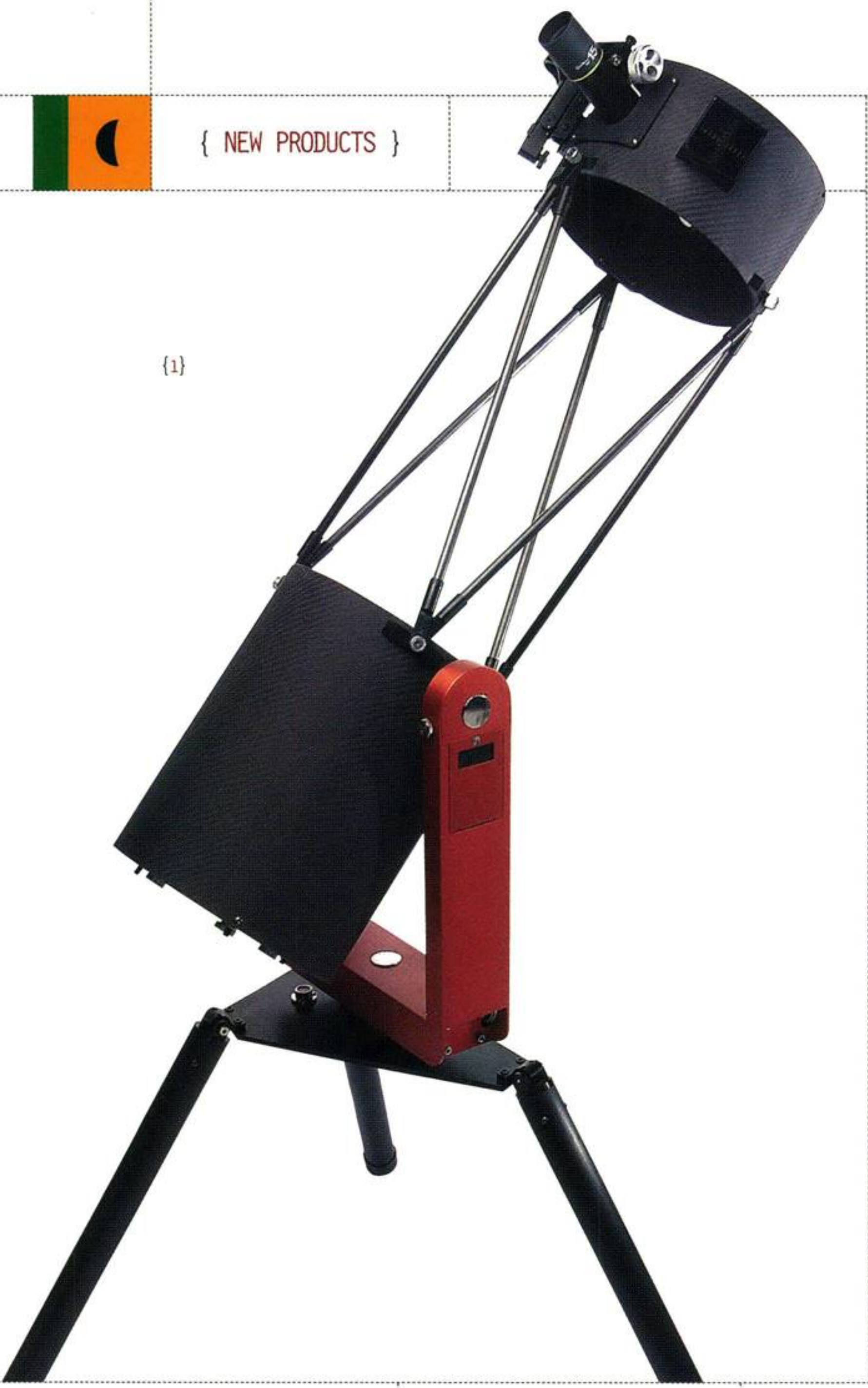

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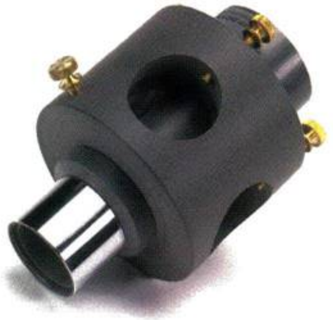

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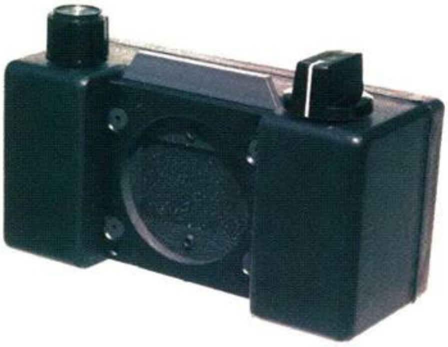

1. Uti
In less than three minutes, you can set up this new 8-inch travel scope, which weighs just 22 pounds and breaks down to fit in a two-foot-long case. Made of carbon fiber and aluminum, the f/4.5 Uti includes a truss shroud, tripod, and case. Its wireless go-to feature works with free Palm Pilot software you can download from the company's website.

$3,295; Infinity Scopes
P. O. Box 69207, Oro Valley, AZ 85737;
[t] 520.248.0932;
[w] www.infinityscopes.com

2. Multi-Eyepiece Turret
Fumble for eyepieces no more with this handy turret that mounts on your focuser. The outer sleeve rotates so you can cycle through four different eyepieces without removing and attaching each separately. About the size and weight of a mug of coffee, the turret is easy to set up and connects securely to your scope with a long focuser tube nose.

$124; Seven Wonders Optics
719 Gabardine Avenue, Portage, MI
49002; [t] 800.569.6633;
[w] www.sevwon.com

3. Power Mac G4
If "glacial" best describes your computer's speed, try Apple's latest offering of Power Mac G4s. They run on dual processors that range from 867 MHz to 1.25 GHz. And software such as *Stargazer's Delight* and *XEphem* will look better than ever on the new 23-inch flat monitor, which displays all-digital images with a resolution of 1,920 by 1,200 pixels.

G4s from $1,699; monitor $3,499
Apple, 1 Infinite Loop, Cupertino, CA
95014; [t] 800.692.7753;
[w] www.apple.com

4. HyperCamera
Moisture can be the bane of an astrophotographer's existence. It slows film speeds, which must be fast to register in dim light. The 35mm HyperCamera fights this effect with a desiccant that lasts through 10 rolls of film. Also, its two gas ports can be connected to a nitrogen tank in humid environments. The nitrogen shields the film from damage.

$229; Taurus Technologies
P. O. Box 14, Woodstown, NJ 08098;
[t] 856.769.4509;
[w] www.taurus-tech.com

Join the editors of *Astronomy* magazine on an astronomy tour of HAWAII!

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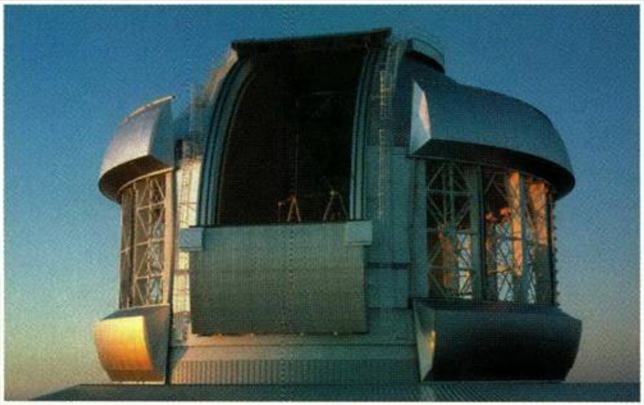

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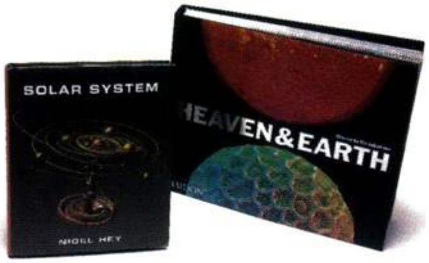
From the solar system to heaven



DESKTOP UNIVERSE

Solar System

Nigel Hey, 272 pages, Weidenfeld & Nicolson (distributed in the U.S. by Sterling), New York, 2002; ISBN 0-3043-5994-7; hardcover, $29.95.

"Hang on, and enjoy the ride," Nigel Hey tells us as he gears up for a whistle-stop tour of our planetary neighborhood. Besides sightseeing stopovers from Mercury to Pluto, Hey's trip also takes in the mechanics of mission design, the politics of space agency funding, and human colonization of nearby planets.

As a former information officer for NASA's Galileo project, Hey seems ideally qualified to take on this snapshot encyclopedia project. The book amasses a wealth of detailed, up-to-date technical information on space missions, particularly the Saturn-bound Cassini probe. Style-wise, though, the engaging enthusiasm of Hey's introduction quickly dwindles, and the book's first half becomes a dry delivery of facts and figures reminiscent of an undergraduate engineering text. More on the personalities of the scientists themselves would have provided welcome warmth and color.

Also, discussion of mission funding politics is sparse. A brief section on the space race peaks nicely with Kennedy's admission that he was less interested in space for space's sake than in beating the Russians to the Moon. However, readers seeking a perspective on more contemporary political issues — for example, China's avowed plans to put astronauts on the Moon — will have to look elsewhere. The book would benefit from more discussion on how the world's slimmed-down space agencies obtain funding now that the public's fascination with space exploration has abated.

The book's faint turquoise hue, when seen side-on, results from a smattering of coded green and blue pages. Green pages seem filled with extra technical information, ranging from binary code and space propulsion to astronaut physiology and extraterrestrial life. These info-dumps break up the narrative flow, particularly since there is no evident logic for their positioning within the book. A discussion of whether life arrived on Earth aboard a meteorite appears rather incongruously in the chapter on Jupiter and Saturn, rather than the one devoted to our planet.

Blue sections indicate guest essays contributed by such luminaries as Arthur C. Clarke and Freeman Dyson. Their two short contributions — on the projected evolution of minds and machines — are arguably the best parts of the book. Their inclusion, though, is problematic for three reasons: They weren't written for the book; they aren't about the solar system; and their evocative style does nothing to help resign the reader to Hey's own rather workaday prose.

The book is most enjoyable when the tour resumes a more standard planet-hopping format. Hey takes us through the history of observations of our celestial neighbors, while pointing out there is still much to learn about the solar system's barely explored outer reaches. Perhaps this more traditional approach, while still incorporating mission details, would have made *Solar System* a more satisfying tour. In its current format it's too dense for the novice tourist and too messily arranged to be a useful reference for seasoned travelers. It's a fun tour destination, but the package needs improving. — **ALISON BOYLE AND KEN GRIMES** *are freelance science writers living in London.*

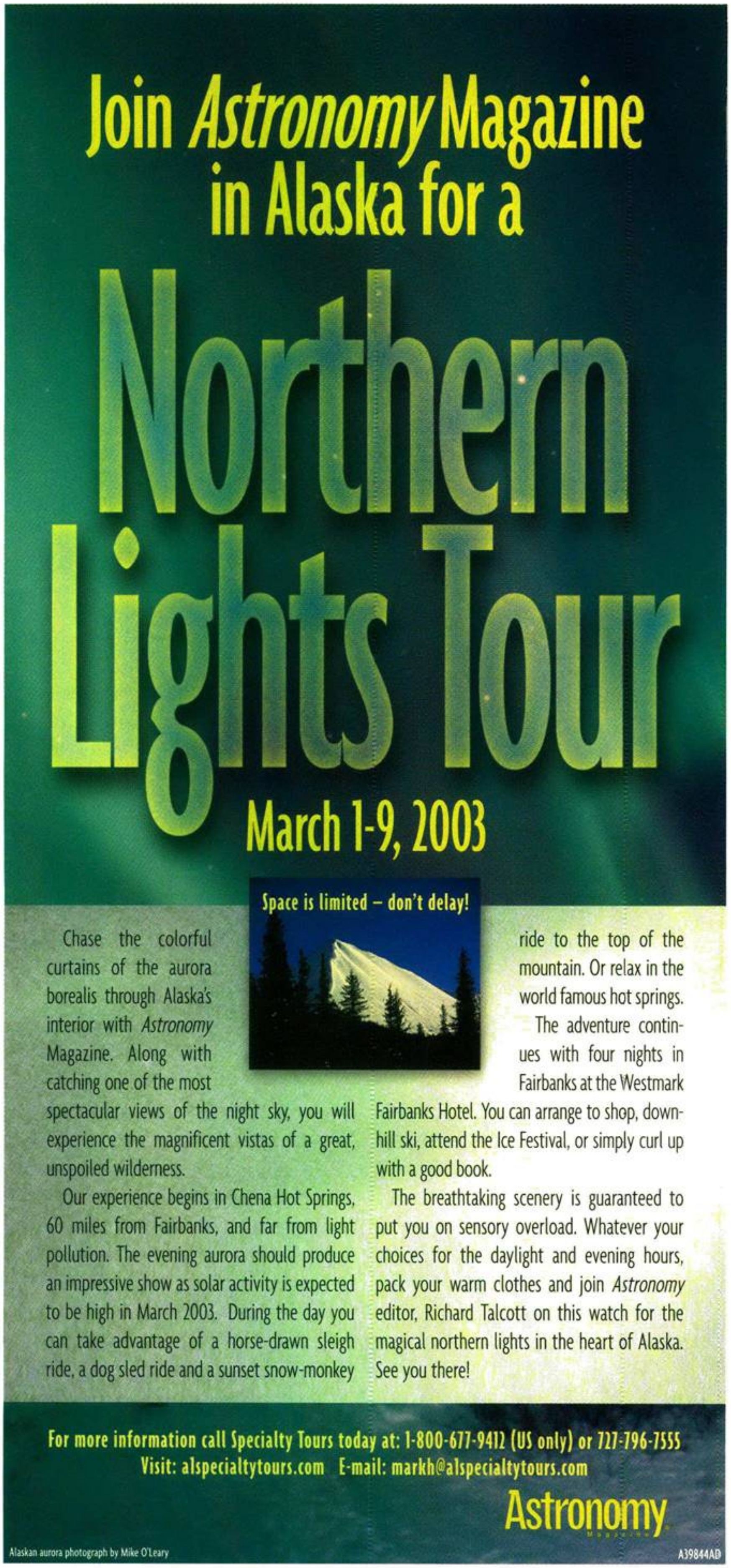
Heaven and Earth: Unseen by the Naked Eye

David Malin and Katherine Roucoux, 384 pages, Phaidon, New York, 2002; ISBN 0-7148-4280-X; hardcover, $49.95.

This hefty coffee table book promises to expose fascinating, strange, and beautiful worlds that are invisible to the eye alone. As astronomer and photographer David Malin writes in the preface, "We are in fact blind to all but the thinnest slice of the universe in which we live." Malin has contributed more than 30 of his own images to this collection, which sweeps from the microscopic to the astronomical.

The opening image shows a confusion of yellow trails — traces left by subatomic particles in a bubble chamber. The book then explores viruses, insect appendages, and fingerprints before revealing a collection of satellite photos ranging from reefs and rivers to cities and storms. It then enters space for a look at the solar system, including volcanoes on Venus, Jupiter's moons, and Halley's Comet. The closing chapter peers even deeper — at the Milky Way and objects in it like the Horsehead Nebula, and beyond to other galaxies. The final, remarkable image, courtesy of the Hubble Space Telescope, reveals thousands of distant galaxies that lie near the edge of the observable universe.

The images are both notable and surprising, including the first x-ray images, early photographs of the Moon's surface, and channels on Mars from water that once trickled across its face. A scanning electron micrograph captures the moment of conception as a human sperm burrows into an egg cell, while another tableau memorializes death as a Venus Flytrap ensnares a bush cricket. The jux-



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Astronomy Magazine

Alaskan aurora photograph by Mike O'Leary

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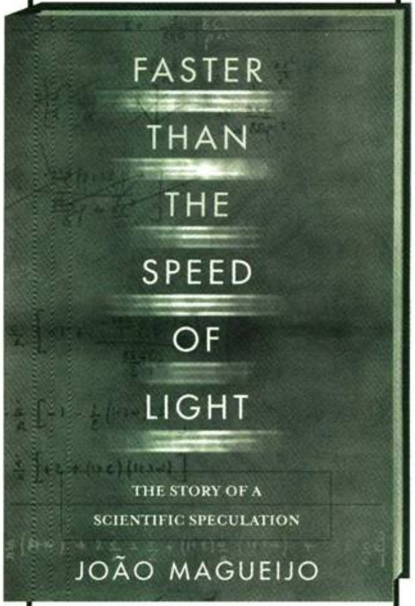
Was Einstein Wrong?


FASTER THAN THE SPEED OF LIGHT
THE STORY OF A SCIENTIFIC SPECULATION
JOÃO MAGUEIJO

João Magueijo, a theoretical physicist at London's Imperial College, has a groundbreaking new theory that challenges Einstein's theory of relativity—and may forever change the way we look at the universe. In his extraordinary new book, Magueijo dares to challenge long established ideas—indeed the most sacred laws of physics. The story of a scientific quest like no other, *Faster than the Speed of Light* provides the first real glimpse of twenty-first-century physics.

"One of the more scathing scientific memoirs of recent years ...irresistible."

—*Kirkus Reviews* (starred review)

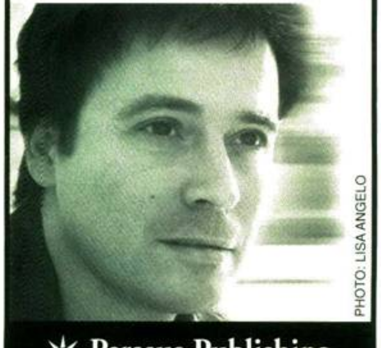


PHOTO: LISA ANGELO

Perseus Publishing
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www.perseuspublishing.com

taposition of such diverse subjects should appeal to scientists and artists alike.

Detailed captions offer quick insights into the science behind each image. And *Heaven and Earth* includes one of the more unusual glossaries you'll see — it begins with "accretion disk" and ends with "zooplankton."

Malin's preface, in which he ponders the wonders and limitations of sight and the techniques that allow us to see the previously unseen, verges on cloying, but it's a small complaint. This is, after all, a coffee table book, so the preface and explanations rightly take a backseat to the magnificent collection of images from near and far. — **ANNA DAVISON** *is a freelance photographer and a reporter at The Santa Barbara News-Press.*

Desktop Universe

Main Sequence Software, Windows 95/98/2000/XP/ME/NT, $299.
[w] www.main-sequence.com
[t] 613.226.5042.

Five years in the making, *Desktop Universe* from Main Sequence Software utilizes more than 20,000 images from both the Northern and Southern hemispheres. The result is a seamless photographic planetarium that allows you to view stars and deep-sky objects down to magnitude 14.

Available for Windows only, its hardware requirements may be quite demanding for those with older PCs because it runs directly from the hard drive. You'll need at least a 500MHz processor, 256Mb of RAM, a color monitor, a CD-ROM drive, and an entire gigabyte of hard-drive space. The software is ideal for use in the field with a laptop.

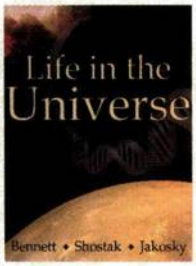
The program itself is pretty straightforward. Once you've set your observing location, you can specify the date and time for the sky view you'd like to see. You can also find objects with a searchable database, then zoom in on them for a better glimpse.

Other features include plotted outlines for deep-sky objects; the positions of the Sun, Moon, planets, asteroids, and comets; constellation outlines and boundaries; ecliptic and horizon lines; and field-of-view markers. The program can plot white dots over the photographs of stars to help identify constellations. Also, variable stars and novae are circled, but surprisingly, double stars are not singled out in any way.

Also missing are the satellites of Jupiter and Saturn. Although the Moon is graphically depicted, its phase sometimes appears at a peculiar angle to the lunar pole. Another minor gripe is the inability to jump to a specific right ascension and declination in the sky, an option that could prove useful when tracking a newly discovered comet or asteroid.

Where the software truly shines is in image quality. It's fully compatible with the ASCOM telescope interface, so try setting the screen to monochrome and then adjusting the color and contrast to match the view through your eyepiece. The chart can also be flipped and reversed, and a nighttime setting helps you keep your eyes' sensitivity to the dark. Finally, slide shows and screenshots can be produced for presentations, making the software a viable option for use in schools and local astronomical societies.

At nearly $300, it's not cheap — but when you consider the time and dedication invested in the program, it's worth every penny. If you've ever been disappointed with a "photo-realistic" planetarium program before, you can thank your lucky stars for *Desktop Universe*.
— **RICHARD BARTLETT** *maintains a website on astronomy at www.starlore.net.*

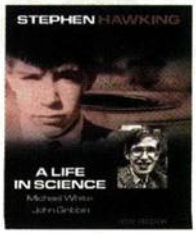


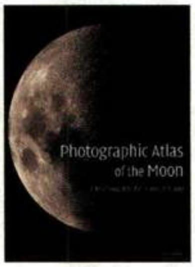
Life in the Universe

Jeffrey Bennett, Seth Shostak, and Bruce Jakosky, 346 pages, Addison Wesley, San Francisco, 2002; ISBN 0-8053-8577-0; softcover, $80.
Whether you're curious about the development of life on our planet or beyond, you'll find an engaging and lucid introduction to astrobiology in this lavishly illustrated textbook from three scientists-cum-educators. Chapter topics include the geological history of the Earth, DNA, and interstellar travel.

Stephen Hawking: A Life in Science, 2nd edition

Michael White and John Gribbin, 360 pages, Joseph Henry Press, Washington, D.C., 2002; ISBN 0-3090-8410-5; softcover, $17.95.
No living scientist is as iconic as Stephen Hawking, the brilliant physicist who has done turns on best-seller lists as well as *The Simpsons*. In this updated edition, the authors delve into Hawking's personal and professional history, from his pioneering insights into time travel to his divorce.



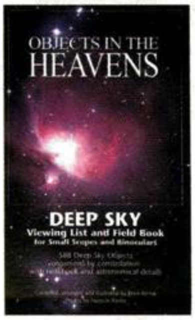


Photographic Atlas of the Moon

S. M. Chong, Albert C. H. Lim, and P. S. Ang, 156 pages, Cambridge University Press, New York, 2002; ISBN 0-5218-1392-1; hardcover, $50.
One of the most spectacular telescopic sights, the Moon is also one of the most overlooked, as it lacks the cachet of exotic deep-sky objects. But in this large-format book, the Moon gets center stage, with four pages devoted to its appearance on each of the 29 days in the lunar cycle.

Objects in the Heavens

Peter Birren, photos by Naoyuki Kurita, 82 pages, Trafford, New Bern, North Carolina, 2002; ISBN 1-5536-9662-X; softcover, $24.99.
[w] www.trafford.com/robots/02-0475.html;
[t] 847.640.0171.
This handy field guide lists 588 deep-sky objects by constellation, object type, location, size, and magnitude, providing intermediate-level amateurs a wealth of information in a clear, compact package.



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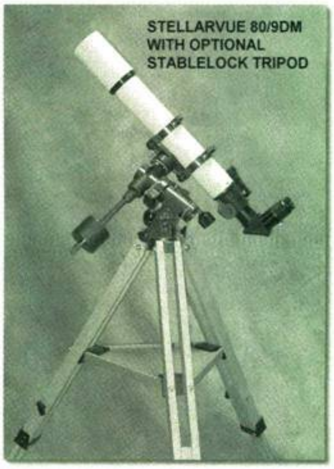

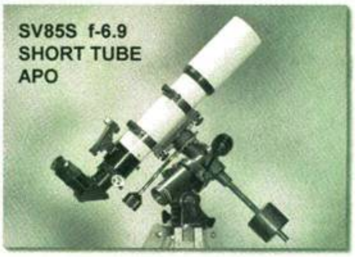

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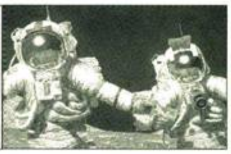

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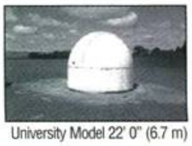
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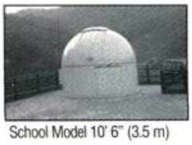
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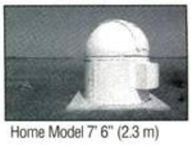
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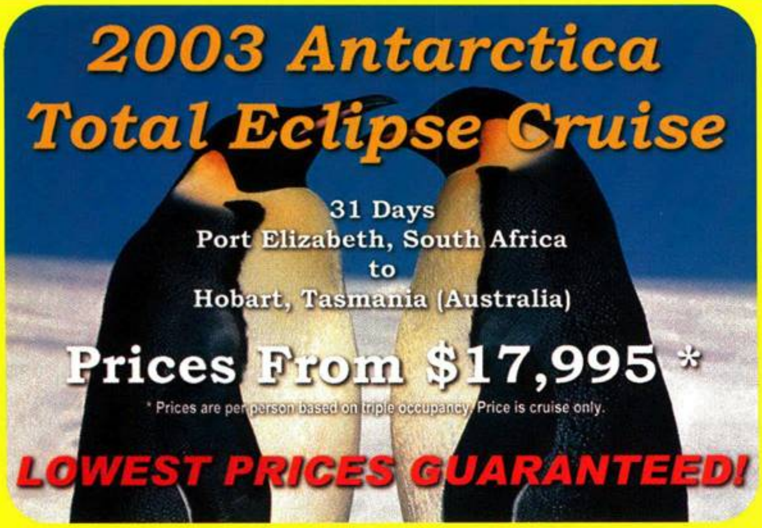

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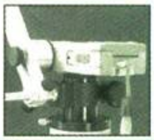

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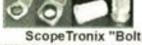

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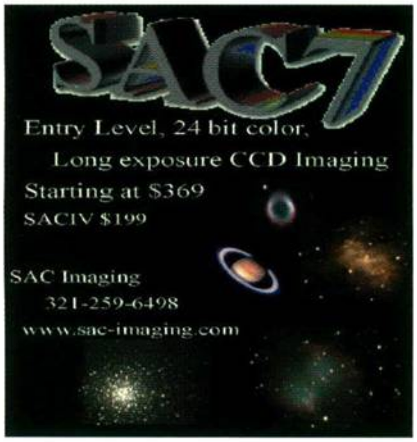

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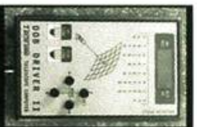

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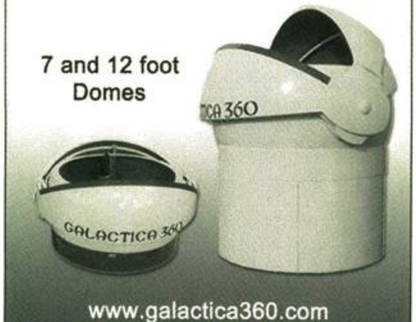

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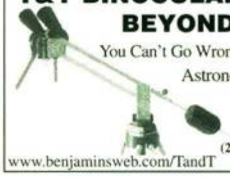

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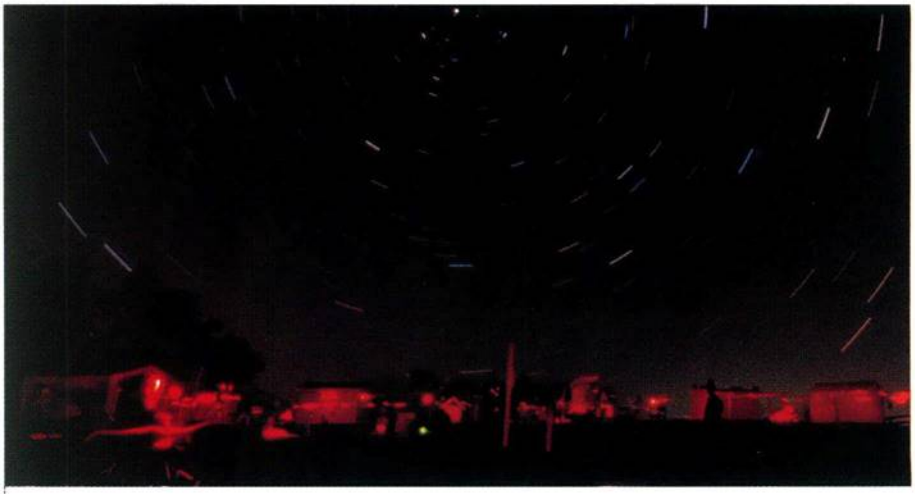
03.27.03–03.30.03

Travel to the piney woods of central Louisiana for this year's Kisatchie Star Party. As in previous years, the event will take place in the Kisatchie National Forest, making the KSP a campout as well as an observing event. From March 27–30, the 5-acre location will serve as a stargazer's paradise, as it provides the darkest skies in Louisiana.



EARLY SPRING'S WARMER WEATHER should encourage observers to attend star parties and reacquaint themselves with the night sky. TERRY ATWOOD

Sponsored by the Baton Rouge Astronomical Society, KSP will include observing, drawings, guest speakers, and an astronomical scavenger hunt. When not peering through the eyepiece, participate in other activities, including hiking, bird watching, canoeing the Kisatchie Bayou, or shopping in nearby Natchitoches.

For more information, contact Don Weinell at 225.644.8604; e-mail, dweinell@eatel.net; website, www.bro.lsu.edu/bras/kisatchie.html.

02.27.03–03.02.03

Mid-Florida Stargaze

Fisheating Creek Campground, Glades County, Florida. The Astronomical Society of Palm Beach will host this event. Observe in a friendly atmosphere away from city lights, high winds, and the salty spray of the ocean. For more information, e-mail stargaze@palmbeachastro.org; mail the ASPB at P. O. Box 19652, West Palm Beach, FL 33416; website, www.palmbeachastro.org/.

03.01.03

Tri-Star 2003

Guilford Technical Community College, Jamestown, North Carolina. GTCC will host this event in association with the Greensboro Astronomy Club. The day will feature a program of guest speakers, displays by vendors, and an evening observing session using the 16-inch scope at the on-campus Cline Observatory. Admission is free and open to the general public. For more information, contact Tom English at 336.334.4822, ext. 2620; e-mail, englisht@gtcc.cc.nc.us; website, www.technet.gtcc.cc.nc.us/comserv/cline/TriStar.htm.

03.08.03

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Russellton, Pennsylvania. Sponsored by the Amateur Astronomers Association of Pittsburgh, this event begins at 4 P.M. The evening will consist of observing and photographing the sky. For more information, visit the AAAP website, www.3ap.org.

03.17.03–03.21.03

Lunar & Planetary Science Conference

Johnson Space Center, Texas. This conference brings together international specialists in petrology, geochemistry, geophysics, geology, and astronomy to present the latest results of research in planetary science. For more information, visit LPSC's website, www.lpi.usra.edu/meetings/lpsc2003/.

03.28.03–03.30.03

South Pacific Star Party

Wirruna, approximately three hours northwest of Sydney, Australia. The SPSP offers an opportunity for amateur astronomers to meet and observe under dark Australian skies. For more information, contact the Astronomical Society of New South Wales at asnsw@asnsw.com; website, www.asnsw.com/spsp/index.html.

03.29.03

All Arizona Messier Marathon

Farnsworth Ranch, Arizona City, Arizona. Sponsored by the Saguaro Astronomy Club, this event begins at 6:45 P.M. All 110 Messier objects will be targeted throughout the night. For more information, contact A. J. Crayon, Deep Sky Chair, at 602.938.3277; e-mail, acrayon@mindspring.com; website, www.saguaroastro.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, Astronomy, P.O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.

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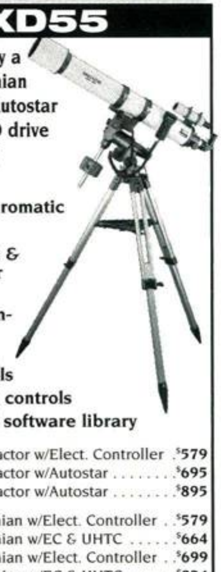

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ASTRONOMY BOOKS

The Deep Sky: An Introduction

By Philip S. Harrington Here is the perfect reference for anyone, who owns a telescope or a pair of binoculars but doesn't know what to look for amid the constellations. It explains how to find double and multiple stars, variable stars, open and gobular clusters, nebulae, and galaxies — what you'll see when you do.Includes 36 full-page sky charts; equipment, books, and software suggestions; sketches of how deep-sky objects look through a small telescope; and more than 100 black & white photographs; 272 pages.

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RESOURCES

Learn more about this issue's topics

DARK ENERGY

BOOKS — Consider reading *The Runaway Universe: The Race to Discover the Future of the Cosmos* by Donald Goldsmith (Perseus, New York, 2000). Written by an astronomer-turned-science writer, this popular book gives an insider's look into the discoveries that led up to the startling finding in 1998 that the expansion of the universe is accelerating.

The Five Ages of the Universe: Inside the Physics of Eternity by Fred Adams and Greg Laughlin (Free Press, New York, 1999) is a worthwhile companion. With scientists' attention to detail, two astrophysicists dissect the far-distant future of the universe epoch by epoch. The book illuminates each stage of decay, from the cosmic distension that will push other galaxies out of sight to the last gasps of the largest black holes. The book has the morbid appeal of a horror movie, but it's all the more gripping because of the underlying truth.

WEB — Lawrence Berkeley National Laboratory is planning a spacecraft mission called the Supernova Acceleration Probe (SNAP) to study dark energy. Further details about the mission may be found at: http://snap.lbl.gov/brochure/. The same organization keeps a science-heavy resource page at http://supernova.lbl.gov/-evlinder/sci.html.

MARS

BOOKS — To learn more about historical views of Mars and the evolution in our understanding of the Red Planet, read *The Planet Mars: A History of Observation & Discovery* by William Sheehan, (University of Arizona Press, 1996). If you are more interested in the technical specs on this nearby world, the decade-old *Mars* remains the best single volume compendium of Mars science. *Mars* was edited by Hugh H. Kieffer, Bruce M. Jakosky, Conway W. Snyder, and Mildred S. Matthews, and is available through the University of Arizona Press.

The Astronomical League published a comprehensive guide to observing the Red Planet, *Mars Observer's Handbook*, by Jeffrey D. Beish and Charles F. Capen.

ARTICLE — For historical background on the martian life question, see "The Red Planet's Colorful Past" by William Sheehan (*Astronomy*, March 1997).

WEB — Malin Space Science Systems has developed and designed imaging instruments to fly aboard recent Mars spacecraft, including Mars Global Surveyor and Mars Odyssey. To view an image gallery containing downloadable images, go to: http://www.msss.com/. Additional information can be found from the Jet Propulsion Laboratory at http://mars.jpl.nasa.gov. The Association of Lunar and Planetary Observers (ALPO) offers tips on observing Mars and recent observations at http://www.lpl.arizona.edu/-rhill/alpo/mars.html. The International Mars Watch, a group formed to exchange Mars data between professionals and amateurs, sponsors a website called MarsNet at http://astrosun.tn.cornell.edu/marsnet/mnhome.html.

NEUTRON STARS

BOOKS — A hefty reference for those interested in the minutiae of neutron stars is *Black Holes, White Dwarfs, and Neutron Stars: The Physics of Compact Objects* by Stuart Shapiro and Saul Teukolsky (Wiley Interscience, Hoboken, New Jersey, 1983).

ARTICLES — University of Illinois astronomer James Kaler provides an overview of neutron stars in "The Smallest Stars in the Universe" (*Astronomy*, November 1991), and author Richard Teske gives a biography of one pulsating neutron star in "The Star that Blew a Hole in Space" (*Astronomy*, December 1993).

WEB — For an introduction to neutron stars, see http://imagine.gsfc.nasa.gov/docs/science/know_l1/pulsars.html or http://www.astro.umd.edu/-miller/nstar.html. Take a virtual trip to a neutron star at http://antwrp.gsfc.nasa.gov/htmltest/rjn_bht.html.

CCD IMAGING

CCD SOFTWARE — Diffraction Limited (www.cyanogen.com), manufacturer of MaxIm DL ($399), an advanced and versatile software that can control most popular brands of CCD cameras, hosts an interesting site. The product allows astrophotographers to process imaging with several specially helpful twists.

Starizona (www.starizona.com) manufactures Anti-Blooming Filter Software ($89) that automatically removes the spikes from overexposed stars in CCD images. A process that used to take hours now takes merely seconds.

TESTING TELESCOPE OPTICS

BOOK — To learn all you ever wanted to know about testing your scope's optics, pick up *Star Testing Astronomical Telescopes: A Manual for Optical Evaluation and Adjustment* by Harold Richard Suiter (Willmann-Bell, Richmond, Virginia, 1994).

ARTICLES — One of the most common problems with a telescope's optics is also one of the easiest to fix. When the optical elements in a telescope aren't properly aligned, or collimated, they may cause a point of light to look lopsided in one particular direction when the scope is on either side of best focus.

To learn how to fix this problem, see the *Astronomy* articles, "How to Collimate Your Telescope" (April 1992) and "Collimating a Newtonian Reflector" (August 2002).

WEB — To see what various optical problems will look like through your telscope, download the Aberrator software for free at http://aberrator.astronomy.net/body_index.html.

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Astronomy Day, May 10, is coming up fast

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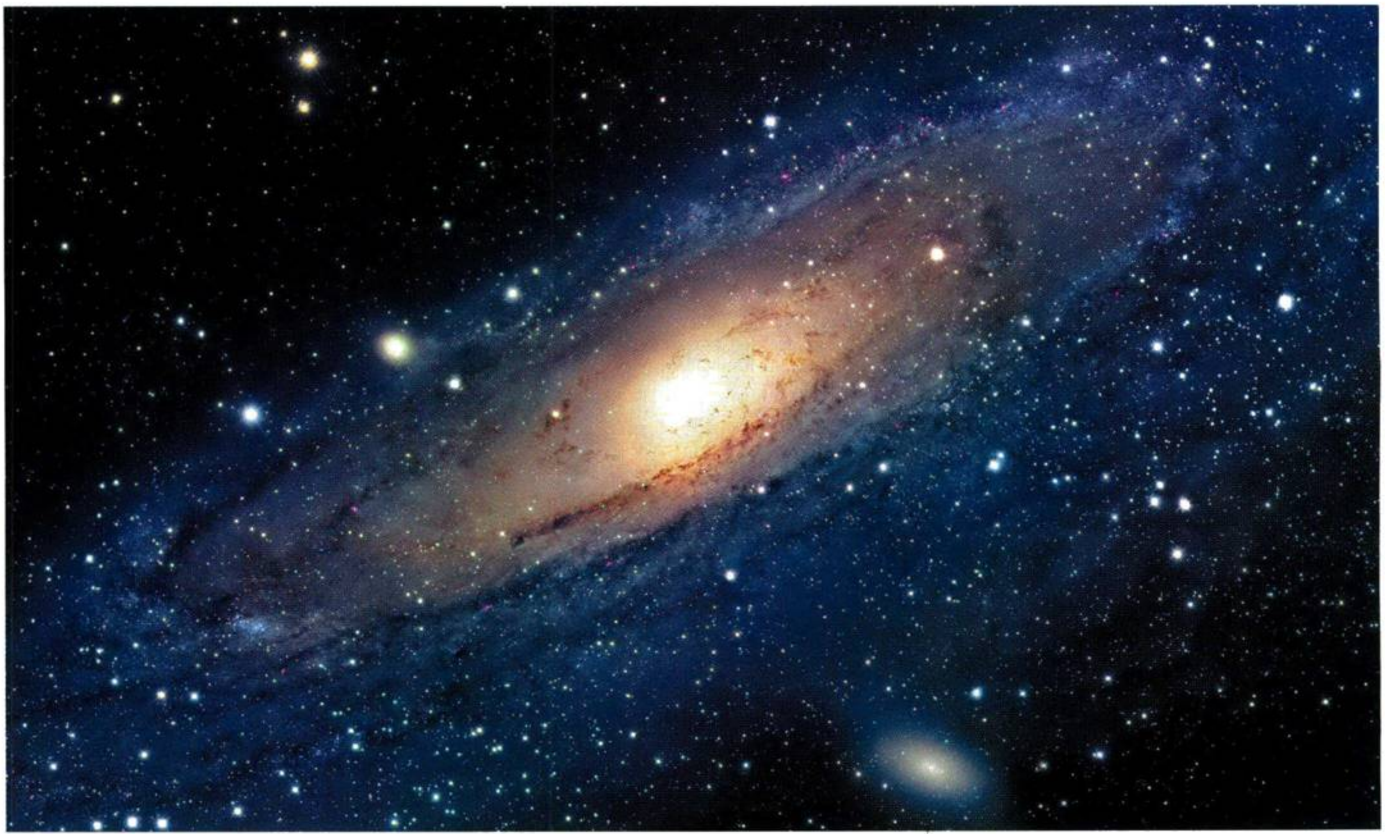
Reader gallery

Readers share their images...

The Andromeda Galaxy /// Aurora and fog over Wisconsin ///
The Sun /// NGC 6894 /// The Pleiades /// NGC 7331 /// NGC 6357 and 6334



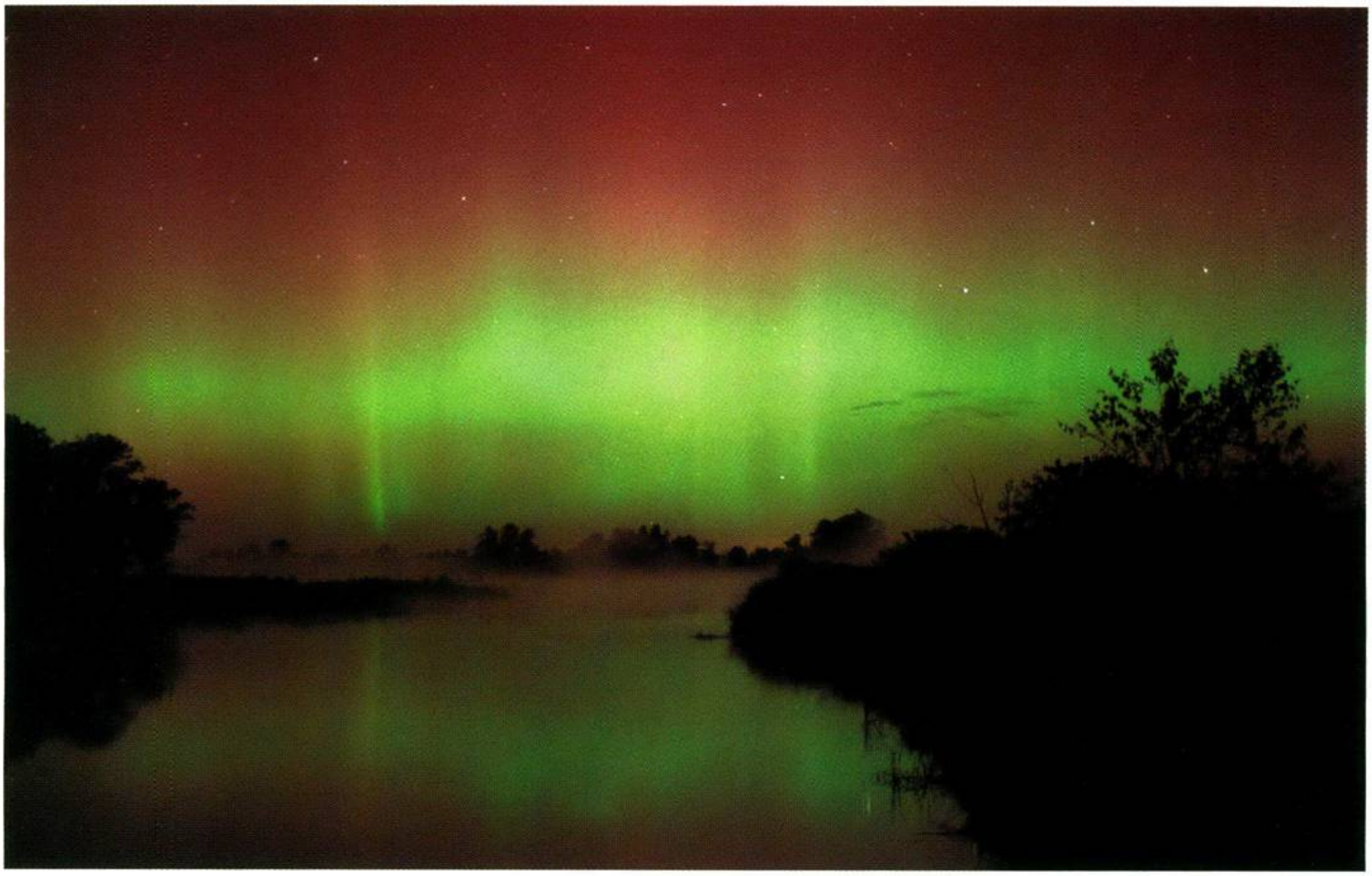
Above, **THE ANDROMEDA GALAXY** (M31); (Optical Guidance Systems 12.5-inch Ritchey-Chrétien scope at f/6, ST-10XME CCD camera) /// **ROBERT GENDLER**

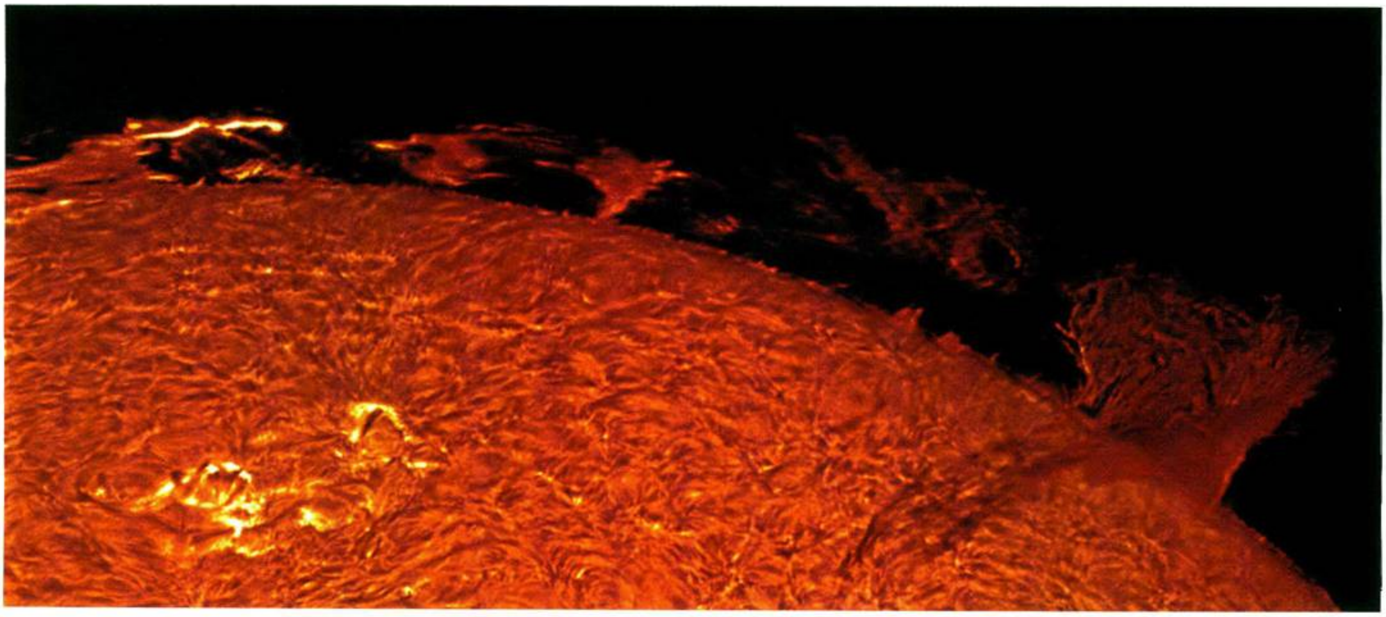
LONG-EXPOSURE ASTROIMAGING

The Andromeda Galaxy (M31)

Robert Gendler captured this gorgeous photo of M31 over 10 imaging sessions. The image is a composite of 40 frames, with a cumulative grayscale exposure time of 40 hours. Color data was then obtained from previous images of M31 to create this beautiful mosaic.

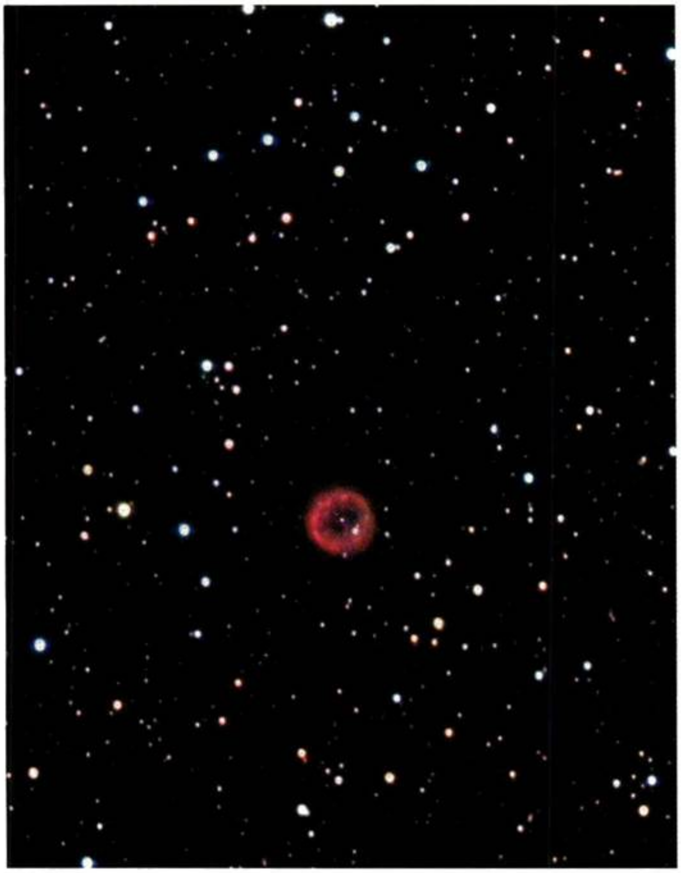
The most distant object visible to unaided eyes, the Andromeda Galaxy lies 2.2 million light-years away and, under a dark sky, appears as a fuzzy, gray-green spike of light. As the closest large spiral to the Milky Way, M31 has always held special fascination for astronomers studying normal galaxies. With approximately 200 billion stars and countless clouds of gas and dust, it offers the best laboratory for extragalactic astronomers to study a big spiral.

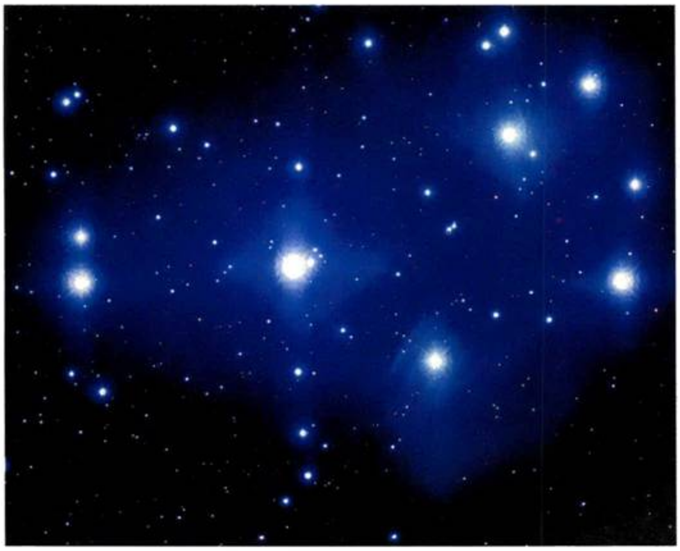


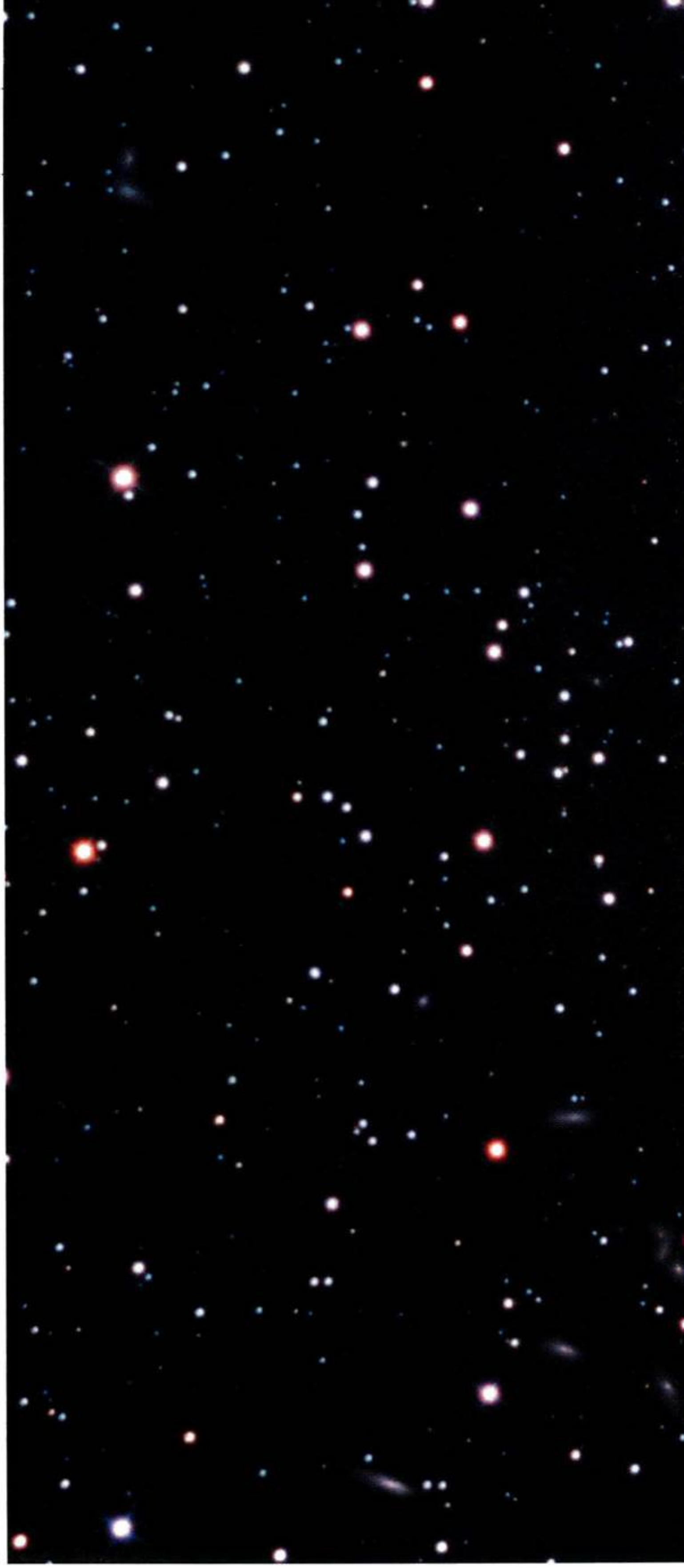


Top, **AURORA** and fog over Wisconsin [24mm lens at f/2.8, Fuji Superia Xtra film, taken October 12, 2001] /// **CHRIS VEN HAUS**

Bottom, **THE SUN** [Meade 5-inch apochromatic refractor at f/32, Pictor 1616XTE CCD camera, Hα filter, taken October 12, 2002] /// **JACK NEWTON**

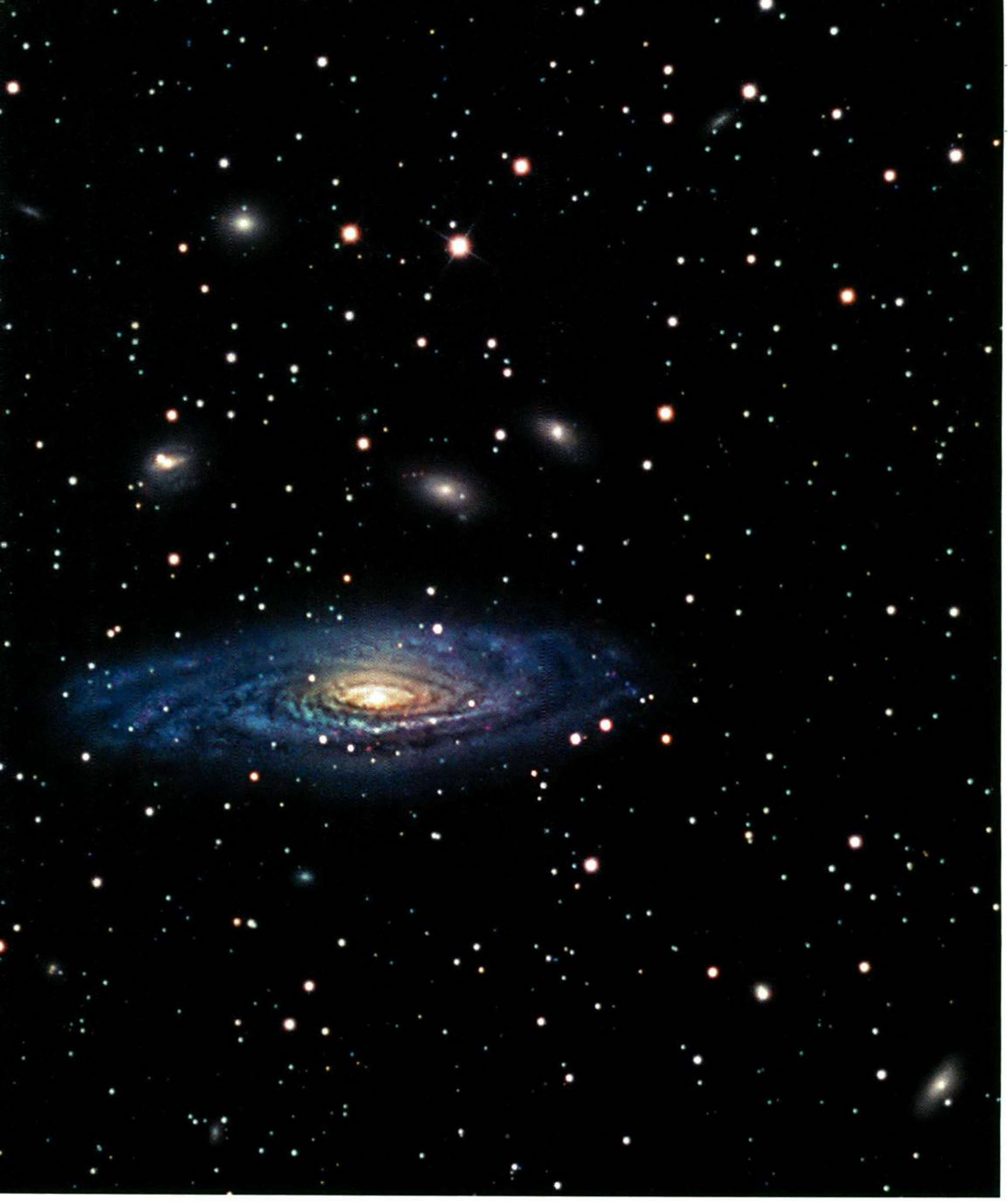






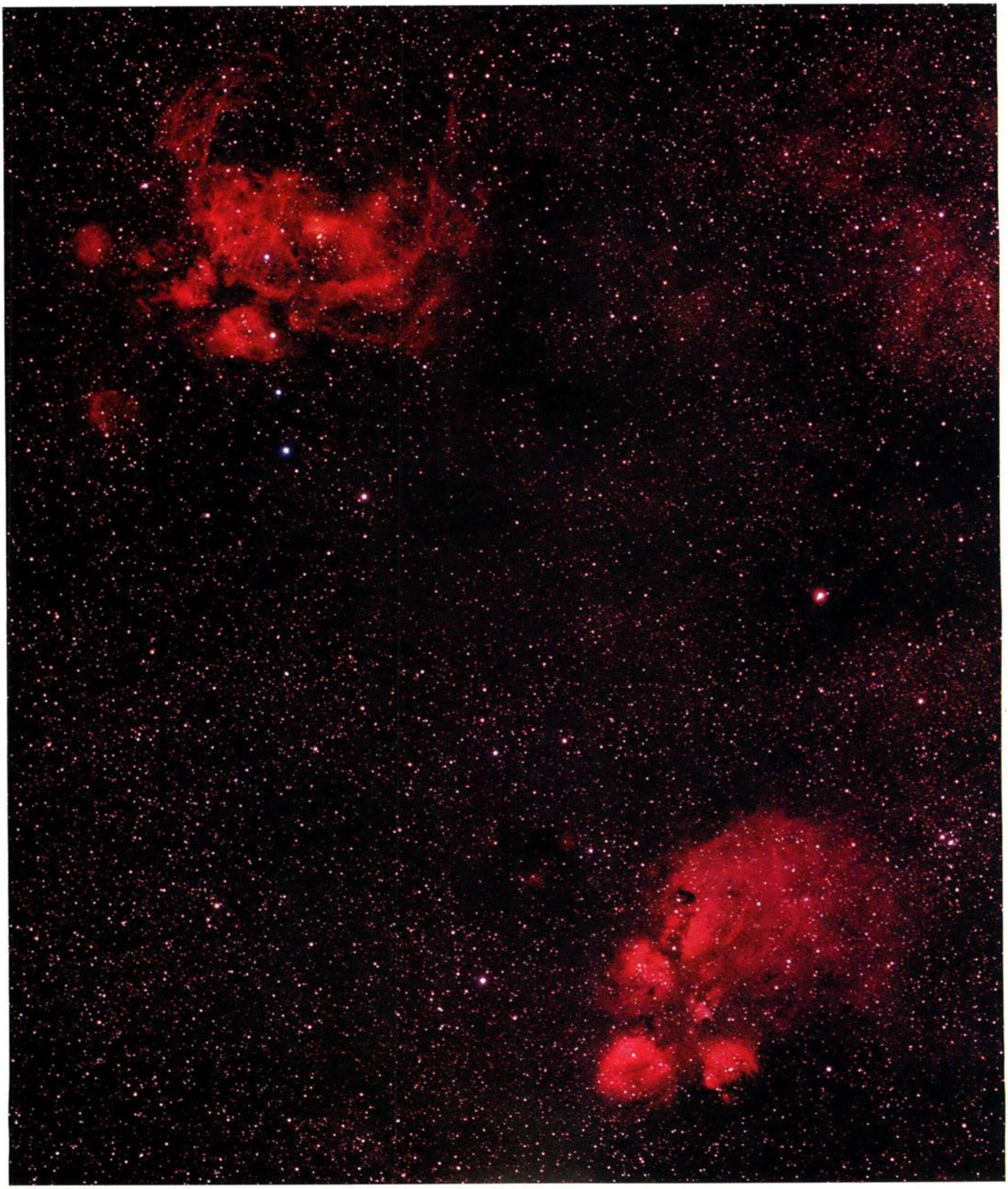
Top left, **PLANETARY NEBULA NGC 6894** [RC Optical Systems 12.5-inch Ritchey-Chrétien scope at f/9, SBIG ST-8XE CCD camera, composite exposure taken September 14, 2002 in Chandler, Arizona]
/// **RICHARD JACOBS**

Bottom left, **THE PLEIADES (M45)** [Takahashi FSQ–106 4-inch apochromatic refractor at f/8, SBIG ST-10XME CCD camera, composite exposure taken October 1, 2002]
/// **MATT RUSSELL**



Above. **SPIRAL GALAXY NGC 7331** in Pegasus (Astrographic 14.5-inch SCT, Kodak hypered 200 film, composite of nine exposures) /// **TONY AND DAPHNE HALLAS**

Below, **THE CAT'S PAW NEBULA (NGC 6334)** and NGC 6357 (Astrophysics 6-inch reflector at f/7, hypered Kodak Pro 400 film, composite of four 45-minute exposures) /// **GEORGE GREANEY**



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Now for a limited time, to celebrate Meade Instruments' 30 years in telescopes, you can buy a Meade telescope* and receive a full set of Meade premium-grade Super Plössl eyepieces for only $99 additional. Never before have we made such an incredible offer available for such a wide range of our most popular telescope models.

Choose from more than a dozen qualifying Meade telescopes *(see listing at right)*, mail us your check for $99, and we'll ship your Super Plössl eyepiece set directly to you. And we'll pack your eyepieces in the Meade #771 foam-lined aluminum carrying case, itself a $49.95 value if purchased separately. For complete details see the HOW TO ORDER box at right.

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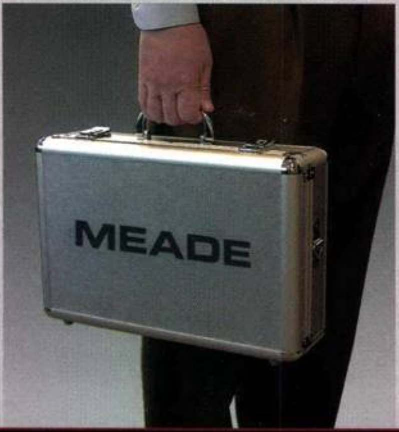

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